ON THE DISTRIBUTION AND ABUNDANCE OF FRY AND JUVENILES OF A FEW CULTIVABLE FISHES IN RELATION TO CERTAIN ENVIRONMENTAL PARAMETERS AT COCHIN

DISSERTATION SUBMITTED BY
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IN PARTIAL FULFILMENT FOR THE DEGREE OF
MASTER OF SCIENCE (MARICULTURE)
OF THE
COCHIN UNIVERSITY OF SCIENCE AND TECHNOLOGY

ICAR
भाकृअप

POST-GRADUATE EDUCATION & RESEARCH PROGRAMME IN MARICULTURE
CENTRAL MARINE FISHERIES RESEARCH INSTITUTE
COCHIN - 682 031

OCTOBER 1989

C E R T I F I C A T E

This is to certify that this Dissertation is a record of work carried out by **Shri. JOYKRUSHNA JENA** under my supervision and that no part thereof has been presented before for any other degree.

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PREFACE

The challenges of providing food for the evergrowing human population, continued exploitation of land, limited scope for cultivation of new areas on land and high investment required to realise marginal increase in fish production from the seas have led to global awareness in recent years to find out ways and means for augmenting the production of finfish and shellfish food through coastal aquaculture. The most important prerequisite to augment fish production is the availability of adequate quantities of seeds of the desired species at the appropriate time.

Estuaries have been aptly referred to as the "door ways between oceans and land masses". It has also been recognised that these regions which are inorganic connections with the sea form an integral part of the overall marine environment. Although the Indian coast line is mostly even and uninterrupted, a number of river systems with their estuaries,extensive backwaters, a few salt lakes and coastal lagoons provide several hectares of water surface that are predominantly brackish. Some seasonal fishery in this water is even in vogue. Apart from this, the investigations conducted in the past have indicated that most of these major brackishwater systems are the sources of fish seed as they form the nursery ground for commercially important cultivable brackishwater species of finfishes and shellfishes which are found to breed in the sea. Since all these species do not spawn under captive and controlled conditions, unlike the cultivable freshwater carps; information on the availability and seasonal abundance of seed of natural water is of vital importance to the development of a coastal aquaculture industry. The ecophysiological conditions in the major estuarine systems have been observed to be highly variable and it is, therefore, imperative that detailed observations in each of the areas chosen for aquaculture feasibility are made and reasonably accurate information on seed availability and abundance maintained.

Cochin backwater is one of the major backwater systems on the south west coast of India. Because of its importance as a nursery ground for many of the cultivable finfishes and shellfishes, and the role it plays in the general ecology as well as economy of the areas, this ecosystem has been the object of intensive studies by several workers. In recent years, the area had been attracting greater attention as the vast stretches of the shallow water regimes are brought under the intensive culture of fishes, crustaceans and molluscs. In order to facilitate the development of these culture fisheries, investigations are being carried out to find out and understand the availability of seed resources of cultivable organisms. In this context, the present study on the availability of fry and juveniles of cultivable finfishes, and their quantitative abundance in time and space would endeavour to add information in proper understanding of seed resource and their exploitation.

The main objective of the present study is to obtain the accurate information on the distribution and abundance of fry and juveniles of the cultivable finfishes in relation to environmental parameters in Cochin backwaters and the intertidal water of the sea in the vicinity of Cochin. This comprehensive study was planned and undertaken since no previous work of such detailed nature on the fry and juveniles of fishes has been carried out in these vast water bodies, known to be the most potential nursery ground for the several finfishes and shellfishes. The study presents the results of the investigation carried out during February to September, 1989.

The results and discussion of this dissertation embody the qualitative and quantitative variation of fry and juveniles of cultivable finfishes in time and space, in relation to the environmental parameters such as rainfall, temperature, salinity, pH, dissolved oxygen, nitrite, nitrate, phosphate, silicate, phyto-plankton and zooplankton.

I wish to express my deep sense of gratitude to my supervising teacher Dr.(Mrs) S. Sivakami, Scientist S-2 Central Marine Fisheries Research Institute, Cochin for her guidance and whole hearted support throughout the course of this study and the preparation of the manuscript. I express my thanks to Dr. P.S.B.R.James, Director, Central Marine Fisheries Research Institute, Cochin for the facilities provided during the tenure of this work. I am thankful to Dr. A. Noble, Principal Scientist for his encouragements. I also wish to thank Mr. M. Srinath, Scientist S-2 for his help in statistical analysis. I am grateful to Mr. K.S. Purushan, Associate Professor and Mr. M.M. Jose, Associate Professor, Fisheries station, Puduvyepu,Kerala Agricultural University, for their whole hearted help throughout the study period. I wish to thank Mrs. T.S. Naomi, Scientist S-1 and Mr. V.K. Balachandran, Technical Officer, for their help during plankton analysis.

My thanks are also to Mr. A. Nandakumar, Technical Assistant, K. Balachandran, Technical Assistant, for their timely help. I express my thanks to all my classmates, senior scholars especially to Miss Sheeba Susan Mathews and Miss Preetha K. for their help.

I would like to acknowledge my earnest thanks to the I.C.A.R for the award of Junior Research Fellowship.

INTRODUCTION

The deepening global food crisis owing to the multiplying population as well as saturation in production levels of agriculture and limitations in the exploitation of natural resource have driven man to one of such ventures as aquaculture to meet the food requirement in future. Though aquaculture, the practice of rearing cultivable aquatic organisms under controlled or semi-controlled conditions has a history that dates back to three thousand years; is still in its infancy as a scientific discipline, even in places where the potential for it is very high. In considering the present and future production through aquaculture, it may be interesting to examine some of the factors that have affected the industry in recent years.

Of all the fishes which inhabit the estuaries, the grey mullets [Mugil cephalus (Linnaeus), Liza parsia (Hamilton), L. tade (Forskål), L. macrolepis (Smith)] and milk fish Chanos chanos (Forskål) are the only two important groups of food fishes routinly cultured in brackishwater in tropical and sub-tropical waters around the world. Even though a number of other species such as the sea bass Lates calcarifer (Bloch), the ten pounder Elops saurus (Linnaeus), the Indian tarpon Megalops cyprinoides (Broussonet), the pearl spot Etroplus suratensis (Bloch) etc. are having the potential for culture, not much attention has been paid towards their culture prospects except for the grey mullets and milkfish.

Availability of adequate quantity of the seed of the desired species at the appropriate time is one of the prime factors that determine the success of culture operation. The seeds that are used as a stocking material are procured either by collecting the fry or juveniles from the natural waterbodies or through controlled breeding.

The artificial breeding of brackish water species of finfishes, that ordinarily breed in the confined water of ponds, is not so well developed as in the case of cultivated fresh-water carps. Even in cases like Mugil cephalus & other mullets it has been experienced that while breeding is relatively easy, hatching and rearing of larvae in commercial quantities pose problems. It is also observed that extremely high mortality of hatchlings occur during crucial period, when the mouth is formed and the larvae start feeding, resulting in the survival rate not more than five percent of the hatchlings through a

42 days long larval period (Liao et al.,1972; Kuo et al.,1973). This is the reason why most fish culturists count themselves lucky if they can rear newly hatched mullet fry for longer than a week. So far successful spawning of milk fish has not been reported in induced breeding by hypophysation.

Due to the above constraints to produce seed under controlled conditions the overwhelming majority of seed used for farming is still collected from natural waterbodies. In nature, the fry and juveniles of different species occur in different seasons of the year in inshore waters and in the estuaries and backwaters. However, their abundance varies from place to place and with seasons, depending on the spawning seasons, spawning intensity, survival of egg and larvae and other ecological variations.

It is well known that the estuarine environment plays an important role on the distribution and abundance of fry and juveniles of cultivable finfishes and prawns. The Cochin backwater system, the largest of its kind in the west coast, though found to be a potentially rich area supporting a diversified population of fry and juveniles, is also the most affected ecosystem at present by human interferences.

The backwaters of Kerala along with its network of anastamosing canal spreads, extends almost throughout the coast line and form important area of fisheries and other human use. It opens into the Arabian sea at Cochin and this facilitates free mixing of seawater with freshwater which flows from the rivers that empty into backwaters. The regular tidal rhythm influences the mixing and flow pattern giving it the features of an estuary. Apart from the tides, the seasonal outbursts of the monsoon have great bearing in controlling the environmental factors which in turn affect the distribution of the fauna and flora in the estuary.

In recent years, several ecological changes have taken place in this ecosystem as a result of man made interference such as deforestation, dredging operations, reclamation processes, releases of pollutants from industries and agriculture and over-exploitation of nursery grounds. Heavy accretion and siltation of sand and silt by Pamba and Periyar river discharge, as a result of acute deforestation have not only reduced mean depth, thus affecting tidal influence in the upper reaches, but also affected adversely the bottom topography and nursery beds. The dredging operations and reclamation processes going on at present in Cochin backwater may have serious impact on the seed resources due to increase in turbidity of waterbody to a larger extent.

Almost all culturable brackishwater fishes differ from the riverine fishes (with spawning period restricted to premonsoon and monsoon seasons) in having prolonged periods of spawning, the breeding season varying from species to species. This necessitates painstaking collection round the year to precisely demarcate the peak periods for collection of their seed.

Extensive investigations on the availability of riverine spawn in time and space have been undertaken in various states of India to furnish information on the quantitative abundance of spawn, its composition and the associated ecological factors. Since no such information regarding estuarine fish seed is available, there is urgent need for similar well planned prospecting.

From the review of literature on the availability of fry and juveniles of brackishwater fishes, it is apparent that in most cases only qualitative information is available. Even when quantitative data are collected, important aspects like numerical superiority of the seed of desirable species, catch per standard effort etc. have not been dealt with. Despite the fact that the distribution of fish fry and juveniles is highly influenced by fluctuations in environmental characteristics, no earnest attempt has hitherto been made in substantiating their correlation. The type of gear to be selected for different environment also depends essentially on the degree of turbulance, velocity of tidal current, tidal amplitude and reversal of current at the turn of tide. Above all, as the methods of collection and reporting have been different among various workers, a comparison of the quantitative data is also difficult.

The information on the distribution and abundance of fry and juveniles of cultivable finfishes in time and space is scanty, considering the vast potential waterbodies of our country. For a judicious exploitation of the resources, it is necessary to have up-to-date knowledge precisely on the magnitude of the available resources and on the environmental characteristics. Important contributions in this line are those by Bal and Pradhan (1951) on the occurrence of fish larvae and post larvae in Bombay waters during 1944-47; Devasundaram (1954) on the fisheries of Chilka lake from 1948-54; Ravish Chandra (1962) on the distribution and abundance of fish larvae in Hooghly estuary; Rao (1964) on the distribution of larvae and juveniles of Mahanadi estuary; Gopalakrishnan (1968) on the collection of brackishwater fish seed from Hooghly estuary; Tampi (1968) on the cultivable marine fish fry resources from brackishwater environment; Rao (1970) on the abundance of larvae and juveniles of cultivable brackishwater fish in the Pulicat lake; Bhanot (1971) on the availability of brackishwater fish seed in Matlah estuary around Port Canning; Rao (1971) on the larval ingress of the milk fish in Pulicat lake; Bhanot and Gopalakrishnan (1972) on the collection of fry of the mullet, Mugil parsia with standard spawn collection net; Gopalakrishnan et al. (1975) on the procurement of stocking material for brackishwater fish culture from Hooghly-Matlah estuarine system; Rao and Gopalakrishnan (1975) on the seed resources and bionomics of brackishwater cultivable fishes of India; Thakur (1975) on the availability of brackishwater fish seed in Kulti estuary, West Bengal; Basu and Pakrasi (1976) on the occurrence of milk fish larvae in the Bakkhali region of lower Sunderbans; Mukhopadhyay and Verghese (1978) on the larvae of Lates calcarifer from Hooghly estuary; Basu and Pakrasi (1979) on brackishwater fish and prawn seed potentialities of Bakkhali area in lower Sunderbans; Rengarajan and David Raj (1979) on the ichthyoplankton of the Cochin backwater during spring tides; Silas et al. (1984) on the spawning ground of milk fish and seasonal abundance of fry along the east and south west coast of India; and Purushan (1989) on the brackishwater fish seed potentialities of Puduvyepu, Cochin etc. Besides these a number of literature are available on the breeding habits and development of estuarine and marine fishes of India which give the idea on the distribution and abundance of seed resource to a considerable extent.

Voluminous literature have been accumulated on the general hydrography and biological properties of Cochin backwaters and other estuarine system which have been the subjects of intensive study since last three decades. Studies on physico-chemical features of the Cochin backwater have been reported by Balakrishnan (1957), Ramamirtham and Jayaraman (1963), George and Kartha (1963), Cherian (1967), Qasim and Reddy (1967), Qasim and Gopinathan (1969), Sankaranarayanan and Qasim (1969), Josanto (1971), Shynamma and Balakrishnan (1973), Wellershaus (1973), Sreedharan and Mohammed Salih (1974), Balakrishnan and Shynamma (1976), Verma et al. (1981) and Lakshmanan et al. (1987). At the same time qualitative and quantitative study of plankton and its distribution in relation to environmental parameters are studied intensively in this waterbody by George (1958), Nair and Tranter (1971), Menon et al. (1971), Gopinathan (1972), Haridas et al. (1973), Devassy and Bhattathiri (1974), Joseph and Pillai (1975), Kumaran and

Rao (1975), Madhupratap and Haridas (1975), Pillai et al. (1975), Rao et al. (1975), Silas and Pillai (1975), Madhupratap et al. (1977), Madhupratap(1978), Madhupratap and Rao (1979), Jayalakshmy et al. (1986). Besides, the variations in the relative proportions of specific group such as copepods, chaetognaths, hydromedusae, siphonophores, decapod larvae, and cladocerans have been studied by Wallershaus (1969, 1970), Abraham, (1970a, b), Pillai(1970), Pillai (1972), Nair (1972), Srinivasan (1972), Santhakumari and Vannucci (1972), Mohammed and Rao (1972), Pillai and Pillai (1973) and Pillai et al. (1973).

A perusal of literature further indicates that the study of diurnal variation of physico-chemical and biological parameters in the estuaries and backwaters are limited to Godavari estuarine system (Subrahmanyam, 1965; Chandramohan and Rao, 1972), Vellar estuary (Rangarajan, 1958; Vijayalakshmi and Venugopalan, 1973), Zuari estuary (Dehadrai, 1970; Singbal, 1973; Goswami et al., 1979), Mandovi estuary (Goswami, 1974; Singbal, 1976) and Cochin backwaters (George and Kartha, 1963; Qasim and Gopinathan, 1969; Shynamma and Balakrishnan, 1973; Pillai and Pillai, 1974; Balakrishnan and Shynamma, 1976; Madhupratap and Rao, 1979; MPEDA, 1980; Ravindran, 1983),while the information on the diurnal variation of the fish seed resources is lacking except the few reported by Sarojini (1958) on Hooghly estuary; Rao (1971) on Pulicat lake; Basu and Pakrasi (1976, 1979) on the Bakkhali region of lower Sunderbans and James et al. (1984) on the occurrence of grey mullet seed at Mandapam.

From the review of literature, it is clearly understood that no such steps has been taken to study the distribution and abundance of fry and juveniles of cultivable finfishes in Cochin backwaters and the coastal areas around Cochin, known to be highly productive and potentially rich nursery ground for many of the cultivable finfishes and shellfishes, particularly in relation to the environmental parameters. Thus the factors such as, lack of knowledge on the availability of fish seed in space and time, increase in demand for seed resources for culture purpose, man made ecological changes occurring in the environments, indiscriminate fishing causing non-availability of brood stock for further recruitment, over exploitation of nursery beds and failure in procurement of seed through controlled breeding technique, necessitate a detailed investigation on the availability of fish seed and the impact of environmental factors on it, for judicious exploitation of the resource.

It is an established fact that the environmental factors, both physico-chemical and biological, could influence considerably on the distribution and abundance of fry and juveniles of finfishes. Among the hydrological parameters in the estuary, salinity is the most important one, since it regulates the entire biological activities of the ecosystem. The salinity fluctuations are very wide in Cochin backwater system because of the influence of monsoon and consequent run off from land. During the premonsoon season, the surface salinity exhibited considerable increase and may be interpreted as the season of highest salinity when the influence of the seawater is at its maximum through out the estuary. During monsoon, large quantities of freshwater enter the estuary from nearby rivers and from the rainfall, resulting in very low saline condition. With such pronounced seasonal variations in the salinity and associated environmental parameters in the ecosystem, the distribution of fish seed is bound to vary in different gradient systems.

It is well known that generally the tiny seed remain in shallow water where the current is very mild and where the region is rich in required food organisms. These move to and fro in the estuary along the marginal water during tidal rise and fall. Bearing in mind all above facts, the sites selected for the present investigation comprise the shallow marginal backwaters representing lower salinity range and coastal intertidal water of comparatively high salinity.

The present investigations were carried out in Cochin backwater system and coastal intertidal water, adjacent to Cochin, which deals with the distribution and abundance of the fry and juveniles of cultivable finfishes in relation to the environmental parameters such as temperature, salinity, dissolved oxygen, pH, dissolved inorganic nutrients, phytoplankton and zooplankton. The study aims to provide the information on the pattern of recruitment, abundance in space and time, delineating the reasons for the abundance and fluctuation in occurrence of different species.

MATERIALS AND METHODS

The Cochin backwater system, the largest of its kind on the west coast of India extending from Alleppey to Azhikode has permanent connection with the sea at Cochin and Azhikode. The present investigations were made at four selected stations, three of which located in Cochin backwater at Karuthedam (station I) representing backwater system; South Puduvyepu (station II) and North Puduvyepu (station III) both representing estuarine system and vypeen light house (station IV) representing intertidal water of the sea (Fig. 1; Plate 1–4).

The studies were carried out during the period February 1989 to September 1989. However, in station III, the samples could be collected from month of May onwards. The materials for the study were collected from all the four stations simultaneously at every fortnight, on every full moon and new moon days; the time of collection being uniformly between 0800 to 1200 hours. Along with the collection of fish fry and juveniles, the hydrographical samples, phytoplankton and zooplankton were also collected from each station with a view to studying the influence of these parameters on the distribution and abundance

Fig.1. Map showing the location of sampling stations.

Fig. 1

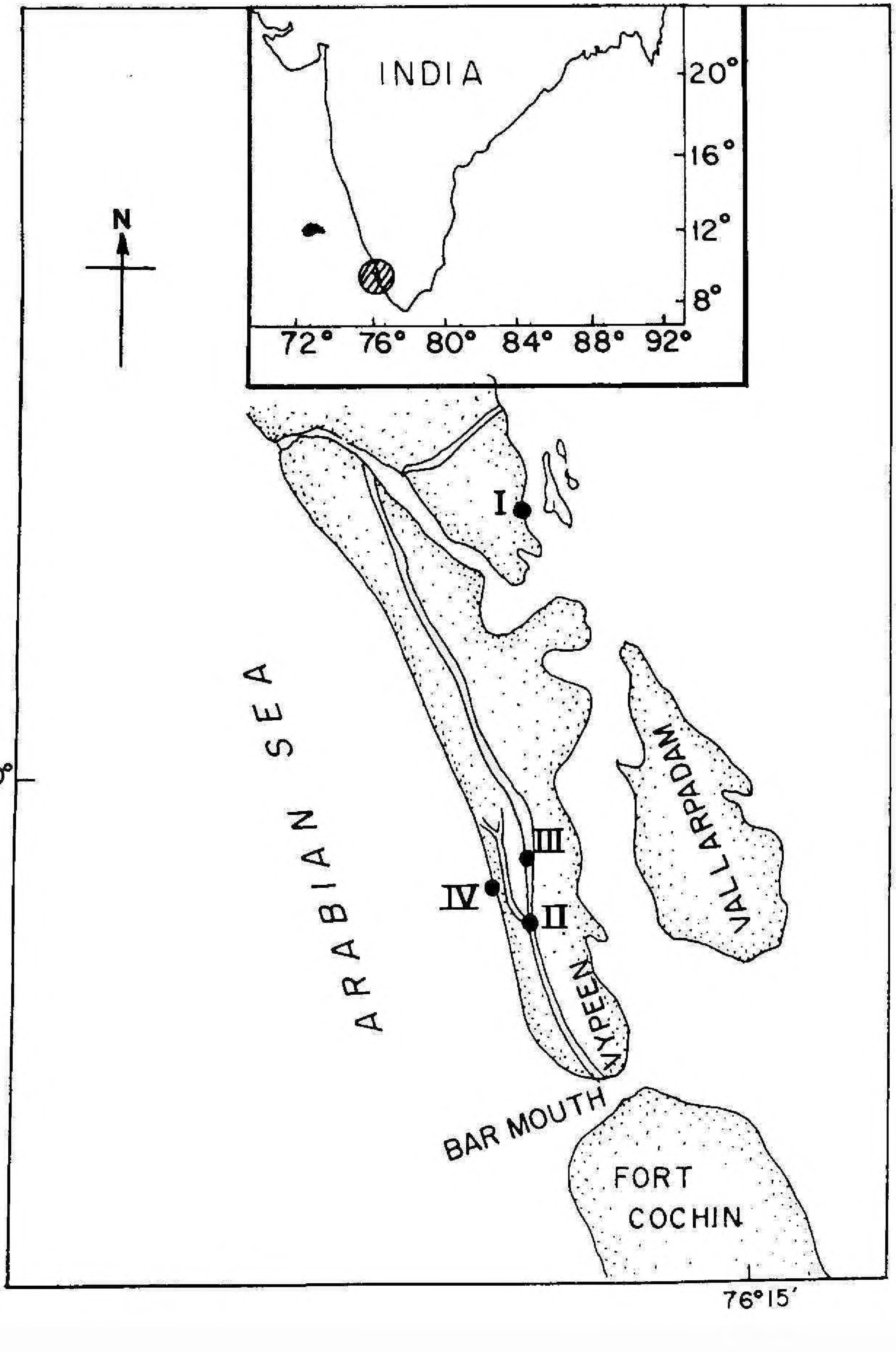

INDIA
20°
16°
12°
8°
72°
76°
80°
84°
88°
92°
N
I
ARABIAN SEA
10°
III
IV
II
VALLARPADAM
VYPEEN
BAR MOUTH
FORT
COCHIN
76°15′

PLATE I: Photograph showing station I.

PLATE II: Photograph showing station II.

PLATE I

PLATE II

PLATE III: Photograph showing station III.

PLATE IV: Photograph showing station IV.

PLATE III

PLATE IV

of fish fry and juveniles. The detailed techniques involved for the collection of each sample and analysis are given below:

Fry and juveniles:

The gears used for the collection of fry of finfishes differ considerably depending on the species of fry to be caught and the nature of the environment from which the seed has to be procured. Midnapore shooting net (Anon, 1965) is the one, which has got wide applicability for the study of the distribution and abundance of fry. But the operation of the same is limited to the regions where tidal fluctuations are appreciable, as it is operated against the direction of water current. Small dipnets made of fine meshed cloth which may be either triangular or circular in shape are also operated for the collection of mullet fry. Sometimes the enclosure net and fyke nets are also used for this purpose (Rajyalakshmi, 1980 and Jhingran, 1983). Besides this, the fry of mullet and bhekti are caught by hapa net, a simple rectangular cloth piece or rectangular bag (mouth 1 m x 0.5 m and length 1 m) made of mosquito netting (Rajyalakshmi, 1980 and Jhingran, 1983). The gears used for the collection of milk fish fry differs from place to place and even from country to country.

It is well known that the tidal influence of Cochin backwater system is of very less magnitude and the stations selected for the present investigations are characteristically different in nature from each other in terms of tidal influence, wave action and topography. Thus keeping in mind all these factors and for maintaining the uniformity in the application of effort, a hapa net was selected for the collection of fry. At the same time a surf net was also used as a secondary gear. The hapa net designed for the purpose was of size 1.8 x 1 m mouth and 1 m length and the surf net of 1.8 x 1 m size. It was operated for 30 minutes at each station by hauling the net at the shallow margin of the selected site of the backwater and by hauling from the far end towards the shore in the inter-tidal water of the sea with the help of two persons. The number of hauls within half an hour and duration of each haul was also recorded. The operation of gear for 30 minutes was considered as one unit effort. The juveniles were collected by operating a cast net of diameter 5 m with the mesh size 8 - 10 mm (from the centre towards the periphery of the cast net). The cast net was operated ten times in every station during each time of sampling and this ten hauls were considered as one unit effort. An experienced fisherman was engaged through out the investigation period for the operation of cast net and other gears effectively. The collected seeds were preserved in 5% neutral formalin at the site and were brought to the laboratory for qualitative and quantitative analysis. The fry of different fishes were identified based on the characters given in the key for identification of larvae (Chidambaram and Kuriyan, 1952; Sarojini, 1958; Rangaswamy, 1978 and 1985; Rajyalakshmi, 1980 and Brave and Jalihal, 1987). Juveniles were identified following FAO species identification sheet for fishery purpose (Fischer and Bianchi, 1984).

Various scales of length measurements are in vogue to differentiate fish fry from juveniles. Since these scales are species specific, a uniform range could not be attributed to demarcate fry from juveniles in the present investigation. Hence, fry collected in fry net and measuring lesser than 35 mm in total length were referred as fry, while those collected in cast net and having a size range more than 30 mm in total length were considered as juveniles.

Hydrography:

The hydrographical parameters studied were water temperature, salinity, dissolved oxygen, pH and inorganic nutrients such as nitrite, nitrate, phosphate and silicate. The water samples were collected by using a plastic bucket. The rainfall data of Cochin for the period of investigation was collected from the daily weather report of Bharat Mausam Vigyan Vibhag, India Meterological Department. The water temperature was measured by using a 0° to 50°C marked ordinary thermometer. Salinity of the water sample was estimated by Mohr-Knudsen method as described by Strickland and Parsons (1968). The dissolved oxygen content of the water sample was estimated by the modified Winkler technique as given by Strickland and Parsons (1968). The estimations were done in the laboratory after fixing the sample with Winkler A and Winkler B solution at the collection site itself. pH of water sample was measured using digital pH meter.

The water samples for the estimation of nutrients were collected in suitable polythene bottles and analysed on the same day after carrying to the laboratory in an ice box. Nitrite-nitrogen was estimated by Bendschneider and Robinson method (Parsons et al., 1984). The absorbance was measured at 540 nm. The nitrate-nitrogen estimation was done according to Morris and Rilay method as described by Parsons et al. (1984). The absorbance was measured at 540 nm. Murphy and Rilay method was employed for the estimation of phosphate (Parsons et al.,1984), where the extinction was measured at

885 nm. Silicate-silicon was estimated by Mulin and Rilay method as described by Parsons et al., 1984. The extinction was measured at 810 nm. Double beam spectrophotometer was used for measuring the extinction for the analysis of nutrients. The same instrument was used through out the period of study to avoid the instrumental errors.

Phytoplankton:

The plankton samples were collected by filtering 100 litres of water from each station, using a 15 litre capacity graduated plastic bucket. A bolting silk net of mesh size 0.069 mm was used for filtering the collected water samples. Immediately after collection the plankton samples were preserved in 5% neutral formalin and examined in the laboratory. The preserved samples were throughly shaken and from each, one ml sample was transferred to a counting chamber (Sedwick rafter cell) and all the organisms contained in it were analysed qualitatively and quantitatively using a compound microscope.

Zooplankton:

Zooplankton samples were collected from all four stations. Horizontal surface tows were made covering a distance of 25 mts with the help of a zooplankton net of 30 cm diameter and of mesh size 0.3 mm. The samples were preserved in

5% neutral formalin for detailed study in the laboratory. The different groups of zooplankton were sorted out, identified and counted numerically with the help of a zooplankton counting tray. The total count obtained was than expressed as the count per cubic metre of water. The dominant forms which constitute the major share of the biomass were identified upto species level.

Diurnal variation:

Since station II and station III were found to be potentially rich in the availability of fry and juveniles, these stations were selected for observing the diurnal rhythm in their distribution. Sampling for diurnal variation was done on the last day of July at every three hours interval, starting from 0900 hours in station II, 1000 hours in station III and continued till the same time of the next day. In addition to the other hydrobiological parameters, the tidal amplitude were also recorded from the wooden poles fixed, both at station II and III.

Statistical analysis:

The results obtained during the present investigation were processed statistically to obtain the mean and standard deviation of each character, separately for the four stations studied. Correlation analysis was also carried out and tested by 't' test (Snedecor and Cochran, 1967) to understand the interrelationship among the hydrobiological parameters and between the hydrobiological parameters and the abundance of fry and juveniles.

RESULTS

The variations in the distribution and abundance of fry and juveniles of cultivable finfishes were observed during the present investigation in all the four stations. Fluctuations in environmental parameters such as rainfall, water temperature, salinity, dissolved oxygen, pH, dissolved inorganic nutrients, phytoplankton and zooplankton were also studied. The variations observed during the period of study are discussed below:

1. METEOROLOGICAL OBSERVATIONS:

1.1. Rainfall:

The fortnightly rainfall during the period of study is given in table 1-4. During the year 1989, Kerala received a copious amount of rainfall. Without exception, Cochin and its adjacent areas also received good quantity of rainfall during south west monsoon. The maximum of 472 mm rainfall was experienced during first fortnight of June followed by 378 mm. during second fortnight of July. The total amount of rainfall recorded at Cochin during the period of study was 227 cm.

2. HYDROGRAPHICAL PARAMETERS:

2.1. Temperature:

Variations in temperature in the four stations are given in table 1-4 (Fig. 2-3). The surface temperature values for the entire period of observation reflected the climatic condition. In station I, the maximum temperature recorded was 32.5°C during month of May and the minimum of 28.5°C during second fortnight of July and August.

In Station II, the maximum temperature of 32.0°C was recorded during May and minimum of 28.0°C during August.

A maximum temperature of 32.0°C during May and minimum of 28.5°C during july and August were observed at station III.

In station IV, the temperature as high as 32.5°C during May and as low as 28°C during July and August was recorded.

In general, the temperature was found decreasing progressively with the onset of monsoon.

2.2. Salinity:

The variations in salinity observed in four stations are given in table 1-4 (Fig. 2-3). Wide fluctuations of salinity were observed during the present investigation in all the four stations. The highest salinity of 13.97‰ was noticed during March and the lowest salinity of 0.54‰ during August in station I.

In station II the maximum and minimum salinity recorded were 23.94‰ during April and 2.25‰ during August respectively.

In station III, the range of salinity observed was from a high of 14.32‰ during May to a low of 1.94‰ during August.

A maximum of 33.65‰ during April and a minimum of 17.19‰ salinity during August were recorded at station IV.

The salinity was fairly high during February to May and the pattern showed a descending trend with the onset of monsoon. From June to September, the salinity was found to be very low in all the stations, including the intertidal zone of the sea (station IV) which showed a decline to 17.19‰ during August. The salinity showed a decreasing trend with increase in distance from the barmouth to the upstream.

2.3. Dissolved oxygen:

Variations of dissolved oxygen are given in table 1-4 (Fig.2-3) for the four stations.

In station I, the concentration of dissolved oxygen ranging between 3.02 ml/l in May to 5.20 ml/l in August, showed wider fluctuations. It is also discernible that the values were high during month of February-April, June, August and September.

With a maximum dissolved oxygen content of 4.30 ml/l during April, station II indicated a decreasing trend during July-September months registering the minimum value of 1.93

ml/l during August.

Station III, studied from the month of May onwards showed a comparatively narrow range of dissolved oxygen concentration with the minimum of 2.62 ml/l in May and a maximum of 4.44 ml/l in July.

Dissolved oxygen concentration, ranging between 3.85 ml/l in June and 5.88 ml/l in April, showed comparatively high values in station IV.

It is also evident that, the dissolved oxygen content showed high values during newmoon phase in all the stations except in station III.

2.4. pH:

The variations of pH for the different stations are given in Table 1-4 (Fig. 2-3).

With the surface water evincing considerable fluctuation in its pH values, premonsoon period recorded maximum values, with the minimum pH prevailing during monsoon months. pH was found increasing again, towards the later period of investigation.

In station I, pH indicated very little variation within the range of 7.17 in July to 7.72 in April. However, during the newmoon phase of August, the value was as low as 6.95.

TABLE I - HYDROBIOLOGICAL FEATURES AT STATION I DURING FEBRUARY TO SEPTEMBER, 1989.

Month		Fortnightly rainfall (mm)	Water temp. (°C)	Salinity (‰)	Dissolved oxygen (ml/l)	pH	Nitrite (µg at/l)	Nitrate (µg at/l)	Phosphate (µg at/l)	Silicate (µg at/l)	Phytoplankton (Cells/m^3)
Febryary	NM	-	31.5	12.32	4.90	7.35	0.65	2.12	2.33	9.2	$194x10^3$
March	FM	5	30.5	13.97	4.85	7.42	0.73	2.04	3.21	17.1	$218x10^3$
April	NM	4	30.5	13.63	4.31	7.64	0.95	2.36	3.11	14.9	$205x10^3$
	FM	88	32.0	12.90	3.95	7.72	0.87	2.20	4.52	14.5	$273x10^3$
May	NM	18	32.5	11.58	3.88	7.53	1.21	2.70	10.75	13.8	$287x10^3$
	FM	254	32.5	9.02	3.02	7.35	0.86	5.39	10.29	12.7	$279x10^3$
June	NM	472	32.0	7.89	4.12	7.59	1.23	8.35	8.21	18.7	$302x10^3$
	FM	343	29.0	2.82	4.54	7.36	1.47	9.40	6.73	26.2	$126x10^3$
July	NM	57	30.0	3.19	3.78	7.27	1.06	5.06	6.79	34.1	$76x10^3$
	FM	378	28.5	1.82	3.27	7.17	1.32	4.29	4.07	79.5	$148x10^3$
August	NM	164	29.5	0.54	5.20	6.95	1.31	6.62	3.05	98.2	$142x10^3$
	FM	47	28.5	1.08	3.57	7.26	1.43	3.89	1.32	34.5	$207x10^3$
	NM		31.0	4.32	3.82	7.29	0.75	5.71	1.69	19.5	$218x10^3$
September	FM	97	31.5	2.25	3.37	7.42	0.88	4.79	2.52	12.7	$268x10^3$
	NM	222	29.5	1.36	4.41	7.45	1.35	3.63	2.07	18.3	$243x10^3$

FM - Full moon, NM - New moon

TABLE 2 - HYDROBIOLOGICAL FEATURES AT STATION II DURING FEBRUARY TO SEPTEMBER, 1989.

Month		Fortnightly rainfall (mm)	Water temp. (°C)	Salinity (‰)	Dissolved oxygen ml/l)	pH	Nitrite (μg at/l)	Nitrate (μg at/l)	Phosphate (μg at/l)	Sliciate (μg at/l)	Photoplankton (cells/m^3)
February	NM	-	31.5	22.93	3.76	7.82	0.75	2.07	3.91	10.5	$365x10^3$
March	FM	5	31.0	23.71	3.20	7.56	0.86	2.45	6 17	18.2	$349x10^3$
April	NM	4	31.0	23.94	4.30	7.45	0.90	2.36	5.63	17.6	$426x10^3$
	FM	88	31.5	21.75	3.73	7.82	0.83	2.40	4.31	16.2	$502x10^3$
May	NM	18	32.0	16.59	2.37	8.03	0.82	2.27	9.90	14.7	$584x10^3$
	FM	254	32.0	14.22	2.95	7.95	0.98	3.75	17.07	18.6	$806x10^3$
June	NM	472	31.0	11.20	3.06	7.78	1.03	4.95	29.23	27.5	$449x10^3$
	FM	343	29.0	5.56	3.84	7.66	1.51	8.60	34.05	36.8	$287x10^3$
July	NM	57	30.5	4.13	3.62	7.62	2.42	6.72	30.70	43.4	$208x10^3$
	FM	378	28.5	5.92	2.89	7.53	1.85	5.35	35.27	93.6	$212x10^3$
August	NM	164	28.5	2.25	2.42	7.25	1.92	5.06	22.04	94.4	$363x10^3$
	FM	47	28.0	3.33	1.93	7.52	1.56	3.59	14.82	41.5	$527x10^3$
	NM		30.0	4.41	2.68	8.02	1.39	2.91	13.31	24.5	$724x10^3$
September	FM	97	31.0	6.57	1.98	7.67	1.84	4.88	11.73	14.8	$731x10^3$
	NM	222	29.5	3.97	2.49	7.88	1.91	3.63	8.97	16.6	$687x10^3$

FM - Full moon, NM - New moon

TABLE 3 - HYDROBIOLOGICAL FEATURES AT STATION III DURING MAY TO SEPTEMBER, 1989.

Month		Fortnightly rainfall (mm)	Water temp. (°C)	Salinity (‰)	Dissolved oxygen (ml/l)	pH	Nitrite (µg at/l)	Nitrate (µg at/l)	Phosphate (µg at/l)	Silicate (µg at/l)	Phytoplankton (cells/m3)
May	NM	18	32.0	14.32	2.62	7.93	0.85	2.46	10.25	21.3	552×10^3
	FM	254	32.0	14.14	2.96	7.85	0.92	4.90	18.70	32.6	696×10^3
June	NM	472	31.5	9.76	3.27	7.72	1.25	4.87	23.41	34.5	402×10^3
	FM	343	29.0	5.21	2.70	7.62	2.65	5.82	27.53	49.0	308×10^3
July	NM	57	29.0	6.73	3.30	7.61	2.23	6.32	26.37	56.2	197×10^3
	FM	378	28.5	5.65	4.44	7.75	2.88	5.28	31.05	89.6	218×10^3
Aug	NM	164	29.5	1.94	3.10	7.27	2.36	4.37	25.93	86.4	253×10^3
	FM	47	28.5	2.79	2.78	7.48	1.82	3.72	16.39	53.9	438×10^3
	NM		30.5	3.78	3.34	8.17	1.25	3.20	18.62	26.7	631×10^3
September	FM	97	31.5	3.77	3.47	8.12	1.39	3.76	12.92	21.9	669×10^3
	NM	222	29.0	2.34	2.98	7.97	1.50	2.19	12.30	17.7	547×10^3

FM - Full moon, NM - New moon

TABLE 4 - HYDROBIOLOGICAL FEATURES AT STATION IV DURING FEBRUARY TO SEPTEMBER, 1989.

Month		Fortnightly raingall (mm)	Water temp. (°C)	Salinity (‰)	*Dissolved* oxygen (ml/l)	*pH*	*Nitrite* (µg at/l)	Nitrate (µg at/l)	Phosphate (µg at"l)	Silicate (µg at/l)	Phytoplankton (cells/m3)
February	NM	-	31.0	33.42	5.62	8.01	0.42	1.22	1.23	1.1	426×10^3
March	FM	5	30.5	32.80	5.45	8.14	0.61	0.91	2.12	1.6	381×10^3
April	NM	4	31.0	33.65	5.88	7.95	0.55	1.23	1.91	1.5	552×10^3
	FM	88	31.5	32.72	5.16	7.92	0.65	1.41	3.35	2.2	623×10^3
May	NM	18	32.5	29.54	4.04	7.83	0.81	1.75	3.25	2.0	960×10^3
	FM	234	32.5	27.34	4.08	7.81	0.93	2.25	4.72	1.8	106×10^4
June	NM	472	31.0	29.00	5.21	7.94	0.75	2.06	5.33	2.0	219×10^4
	FM	343	28.0	23.05	3.85	7.70	0.86	2.73	6.70	4.6	101×10^4
July	NM	57	28.5	23.51	4.06	7.85	1.13	3.31	6.10	6.6	728×10^3
	FM	378	28.0	22.15	5.25	7.67	0.59	1.29	4.59	9.1	590×10^3
August	NM	164	29.0	17.19	4.56	7.48	0.46	1.53	3.05	10.3	562×10^3
	FM	47	29.0	21.62	4.49	7.85	0.63	1.26	2.16	9.3	418×10^3
	NM		28.0	25.46	4.31	7.97	0.71	1.90	1.47	4.5	536×10^3
September	FM	97	30.5	30.14	3.96	7.81	0.33	2.07	1.69	3.9	668×10^3
	NM	222	29.0	25.46	4.62	8.17	0.33	2.13	1.80	5.3	692×10^3

FM - Full moon, NM - New moon

Fig. 2a. Variations of physico-chemical parameters in station I during February to September, 1989.

Fig. 2b. Variations of physico-chemical parameters in station II during February to September, 1989.

Fig. 2

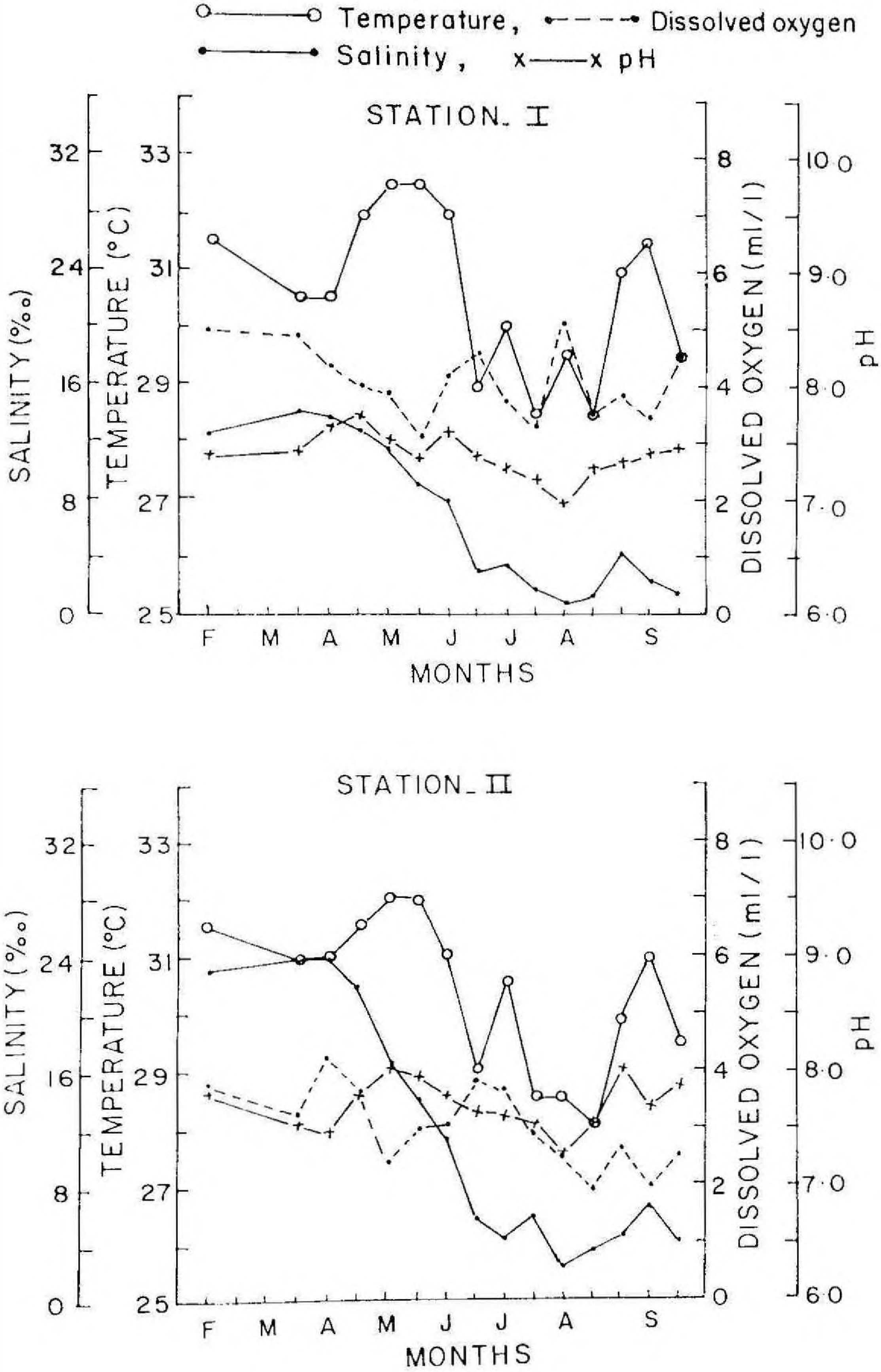
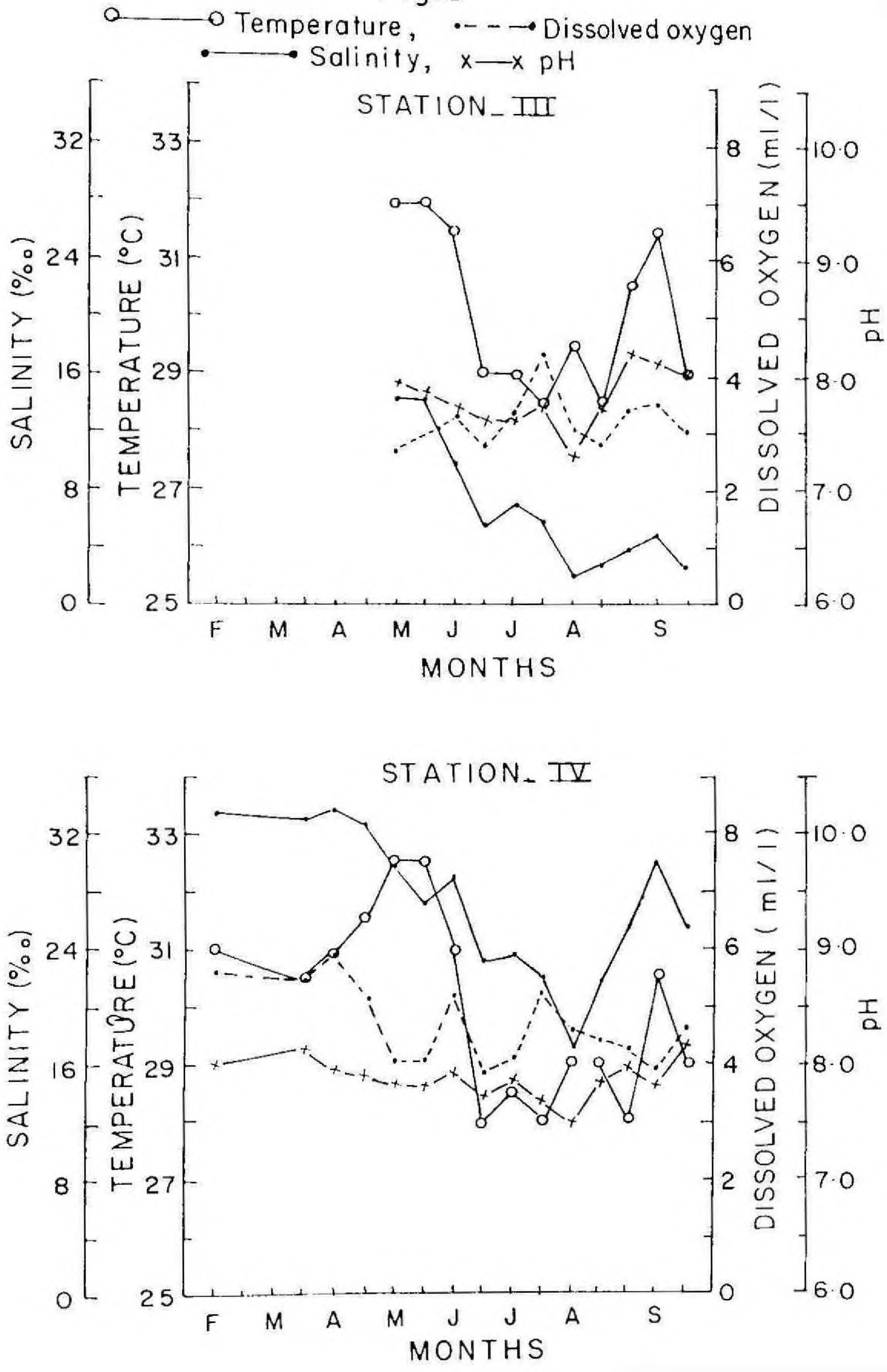

Temperature,
Dissolved oxygen
Salinity,
x——x pH
STATION_I
STATION_II
SALINITY (‰)
TEMPERATURE (°C)
DISSOLVED OXYGEN (ml/l)
pH
32
24
16
8
0
33
31
29
27
25
8
6
4
2
0
10.0
9.0
8.0
7.0
6.0
F M A M J J A S
MONTHS

Fig. 3 Variations of physico-chemical parameters in station III during May to September, 1989.

Fig. 3 . Variations of physico-chemical parameters in station IV during February to September, 1989.

Fig.3



Temperature,
Dissolved oxygen
Salinity,
x—x pH
STATION_III
SALINITY (‰)
TEMPERATURE (°C)
DISSOLVED OXYGEN (ml/l)
pH
32
24
16
8
0
33
31
29
27
25
8
6
4
2
0
10·0
9·0
8·0
7·0
6·0
F M A M J J A S
MONTHS
STATION_IV
SALINITY (‰)
TEMPERATURE (°C)
DISSOLVED OXYGEN (ml/l)
pH
32
24
16
8
0
33
31
29
27
25
8
6
4
2
0
10·0
9·0
8·0
7·0
6·0
F M A M J J A S
MONTHS

In station II, representing the estuarine medium, pH was found higher than in station I throughout the period of study with a minimum of 7.25 during August and a maximum of 8.03 during May.

Station III also indicated higher pH, with the values declining to a minimum of 7.27 in August and increasing thereafter to a maximum of 8.12 towards the later half of the same month.

Of all the stations studied, the intertidal zone at station IV recorded higher values of pH throughout period of investigation with the maximum value of 8.17 registered during September and with the lowest pH of 7.48 recorded during the first half of August.

The pH in general indicated an increase in value with the increase in distance from head stream to the barmouth.

2.5. Nutrients:

The distribution of nutrients in the four stations are given in table 1-4 (Fig. 4-5). The results showed a marked rhythm in their distribution. The concentration of all the four nutrients such as nitrite, nitrate, phosphate and silicate was found to be very low during the premonsoon months but indicated a sharp increase during the monsoon period, followed by steep decline in concentration towards the end of the study period.

The results obtained during the observations are summarised as follows:-

2.5.1. Nitrite:

The nitrite-nitrogen concentration showed an interesting feature in the distribution. The values obtained were considerably low throughout the period except in monsoon in all the four stations.

Station I had a minimum nitrite concentration of 0.65 μg at/l in February, which was found to increase with the onset of monsoon reaching the maximum of 1.47 μg at/l in June. Thereafter, the value registered steady decrease towards the end of September.

In station II, the nitrite concentration was the lowest during February, the value being 0.75 μg at/l. It was noticeable that the nitrite concentration remained low till May, increasing thereafter during the monsoon months to reach a maximum of 2.42 μg at/l in July.

In station III, a sharp fluctuation of nitrite concentration with highest values during monsoon months was noticeable. This station had the minimum value of 0.85 μg at/l in May with the maximum value of 2.88 μg at/l during July.

It was interesting to note that station IV showed very low concentration of nitrite with the lowest value of 0.42 μg at/l during February. Nevertheless, during the monsoon period, comparatively high values could be noticed with a maximum of 1.13 μg at/l during July.

A comparison of the nitrite content in the four stations, indicated very low concentration in station IV, with higher values obtained from station III.

2.5.2. Nitrate:

The concentration of nitrate also followed similar distribution pattern as nitrite with lower values during premonsoon and higher values during monsoon periods.

At station I, the NO_3-N concentration varied between 2.04 μg at/l during March to 9.40 μg at/l during June.

In station II, the values fluctuated between 2.07 μg at/l in February to 8.60 μg at/l in June.

In station III, however, while the nitrite content showed higher values compared to that of station I and II, nitrate indicated reduced concentration. In station III, the lowest value was 2.46 μg at/l in February while the highest value was 6.32 μg at/l during July.

In station IV, the values were comparatively low ranging between 0.91 µg at/l during March and 3.31 µg at/l in July.

2.5.3. Phosphate:

Exhibiting wider fluctuations through time and space, phosphate concentration was found to follow a pattern similar to that of nitrite and nitrate.

In station I, with a minimum value of 2.33 µg at/l during February, the phosphate content showed a gradual increase reaching to a maximum of 10.75 µg at/l in May and declining thereafter reaching to a minimum of 1.32 µg at/l during August. However, the values registered an increase towards the month of September.

In station II, the least concentration of phosphate was noticed in February, the value being 3.91 µg at/l. Exhibiting a higher range upto 35.27 µg at/l during the monsoon period, the phosphate content showed a declining trend thereafter.

Station III, with a concentration of 10.25 µg at/l in February and 31.05 µg at/l in July, was found to maintain a comparatively rich phosphate content with a peak during the monsoon season.

With the phosphate concentration ranging from 1.20 µg at/l in February to 6.70 µg at/l in June, station IV showed lesser concentration especially during pre and post monsoon months under study.

2.5.4. Silicate:

With comparatively high values, silicate concentration was found to follow a fluctuation pattern similar to that of other nutrients studied.

In station I, eventhough the minimum value of 9.2 μg at/l was recorded during February, it shot up to 17.1 μg at/l in March but declined thereafter to increase again during monsoon period, reaching to a maximum of 98.2 μg at/l in August. However, during the subsequent period of August and September, silicate concentration further showed a general declining trend.

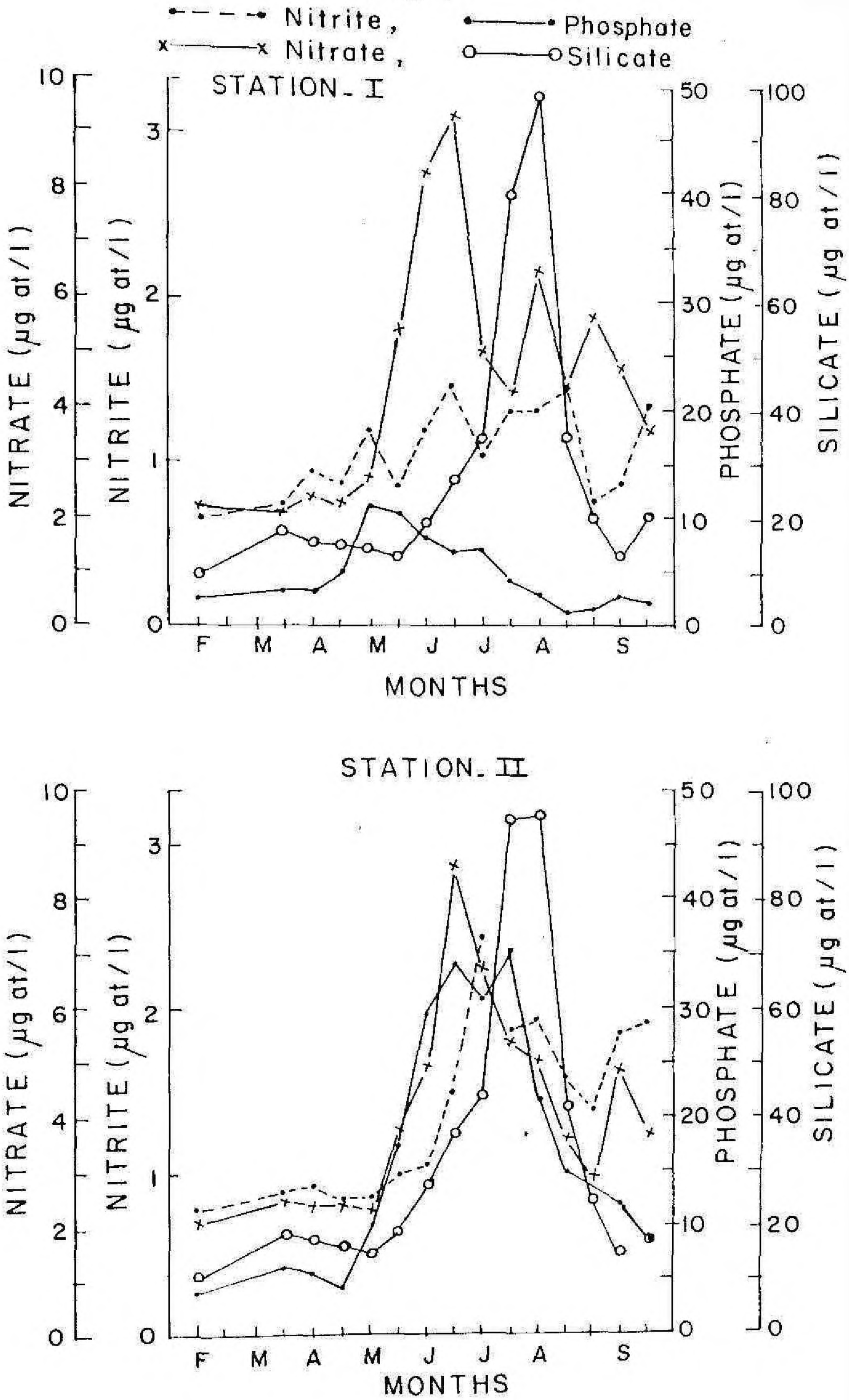
Following the same distribution pattern as in station I, the silicate content in station II ranged from 10.5 μg at/l in February to 94.4 μg at/l during August while in station III the range was within 17.7 μg at/l in September and 89.6 μg at/l in July.

Station IV, though with lower concentration of silicate indicated wider fluctuations with a peak during July; the maximum value recorded being 10.3 μg at/l. The minimum concentration of 1.1 μg at/l was recorded in February..

Fig. 4 . Variations in nutrients concentration at station I during February to September, 1989.

Fig. 4 . Variations in nutrients concentration at station II during February to September, 1989.

Fig. 4

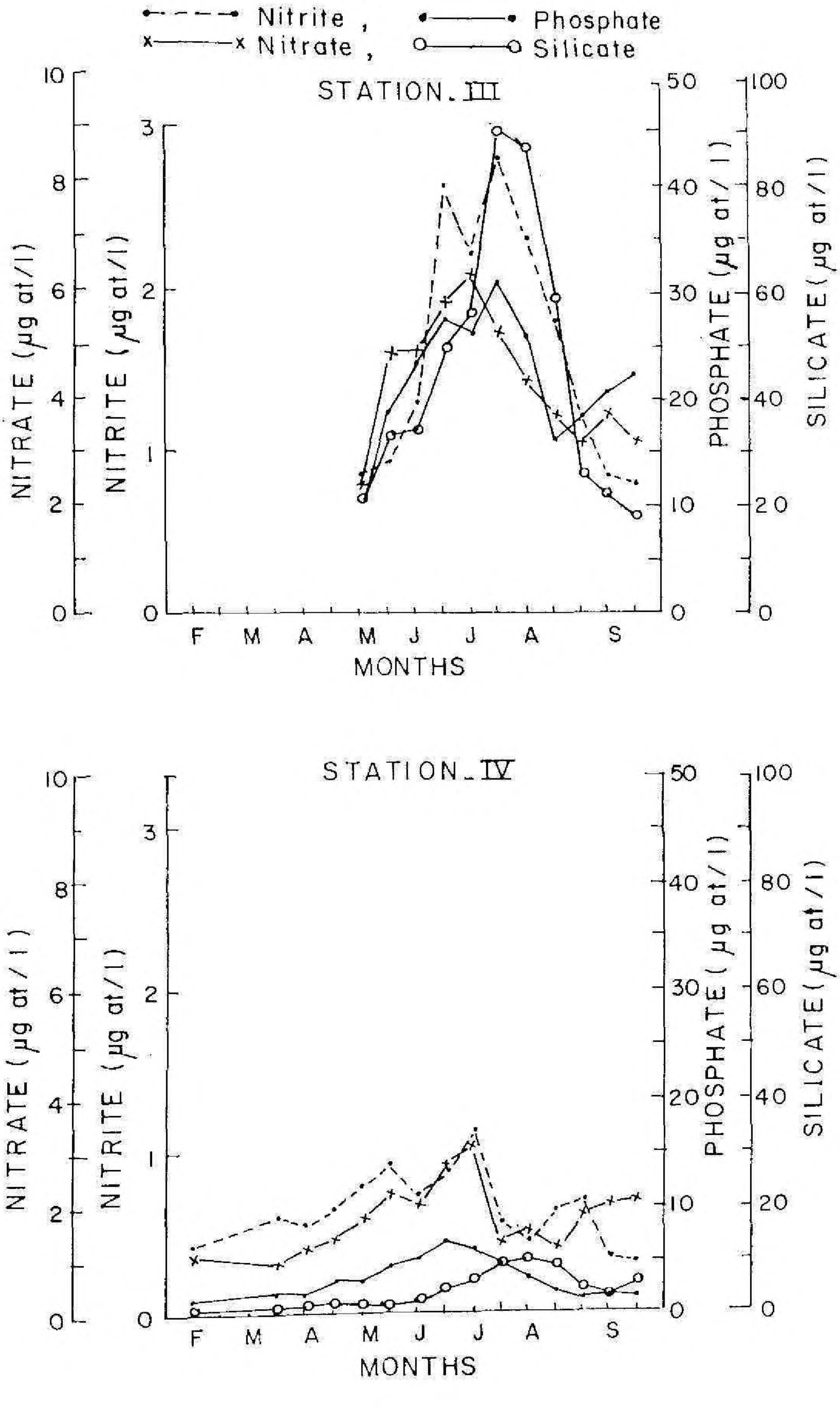


Nitrite,
Phosphate
Nitrate,
Silicate
STATION_I
NITRATE (µg at/l)
NITRITE (µg at/l)
PHOSPHATE (µg at/l)
SILICATE (µg at/l)
F M A M J J A S
MONTHS
STATION_II
NITRATE (µg at/l)
NITRITE (µg at/l)
PHOSPHATE (µg at/l)
SILICATE (µg at/l)
F M A M J J A S
MONTHS

Fig. 5.. Variations in nutrients concentration at station III during May to September, 1989.

Fig. 5·. Variations in nutrients concentration at station IV during February to September, 1989.

Fig.5


Nitrite ,
Phosphate
Nitrate ,
Silicate
STATION_III
NITRATE (μg at/l)
NITRITE (μg at/l)
PHOSPHATE (μg at/l)
SILICATE (μg at/l)
MONTHS
F M A M J J A S
STATION_IV
NITRATE (μg at/l)
NITRITE (μg at/l)
PHOSPHATE (μg at/l)
SILICATE (μg at/l)
MONTHS
F M A M J J A S

3. PHYTOPLANKTON:

The variations in phytoplankton abundance (cells/m^3) in four stations through different months are given in Table 1- 4 (Fig. 6-7).

The concentration of diatoms were relatively high throughout the year (Fig.8), but it was subjected to considerable seasonal variations. The highest concentration of phytoplankton was observed during premonsoon period at station I, II and III and during early monsoon in station IV. Minimum concentration was obtained during monsoon followed by an increase in number again during post monsoon ie. in September, thereby indicating two peaks in all the four stations studied.

In station I, the maximum concentration observed was 302×10^3 cells/m^3 during June and minimum of 76×10^3 cells/m^3 during July.

A maximum of 806×10^3 cells/m^3 during May and minimum of 212×10^3 cells/m^3 during July were recorded in station II.

In station III, the concentrations ranged between 197×10^3 cells/m^3 in July to 696×10^3 cells/m^3 in May.

Very dense populations of phytoplankton was observed in station IV throughout the period of investigation with a maximum of 219×10^4 cells/m^3 during June and a minimum of 381×10^3 cells/m^3 during March.

It is discernible from Figure 8, that phytoplankton abundance was largely contributed by diatoms such as Coscinodiscus spp. Nitzschia spp., Skeletonema spp., Pleurosigma spp. Navicula spp., Rhozosolenia spp.and Biddulphia spp. Among these,Coscinodiscus spp. was found to contribute the highest percentage to the total phytoplankton throughout the year in all four stations except in station II and IV. Skeletonema spp. Biddulphia spp. was found to be dominating during Feb-April and May respectively in station IV. Pleurosigma spp. were found dominating during February in station II. Other species which contributed to the total standing stock are listed in table 5. Among the blue green algae, the species such as Oscillatoria sp. Nostoc sp. and Anabaena sp. were also found to contribute a larger share during monsoon. Anabaena sp. was found to be dominant during the latter part of May and in June in all the stations except in station IV; whereas Oscillatoria sp. was found in huge numbers during June and July in station II and III. As high as 42% of the total phytoplankton was contributed by Oscillatoria sp. during second fortnight of June in station II. Nostoc sp. was found to occur during June to August more or less in same concentration in all the stations, except in station IV. However, among the blue green algae, only Anabaena sp. was noticed in few numbers during 2nd fortnight of May and June in station IV.

Dinoflagellates such as Peridinium spp., Ceratium spp. and Dinophysis spp. were recorded in larger quantities

Fig. 6 . Histogram showing the variations in numerical abundance of phytoplankton and zooplankton in relation to temperature and salinity at station I during February to September, 1989.

Fig. 6 . Histogram showing the variations in numerical abundance of phytoplankton and zooplankton in relation to temperature and salinity at station II during February to September, 1989.

Fig. 6.

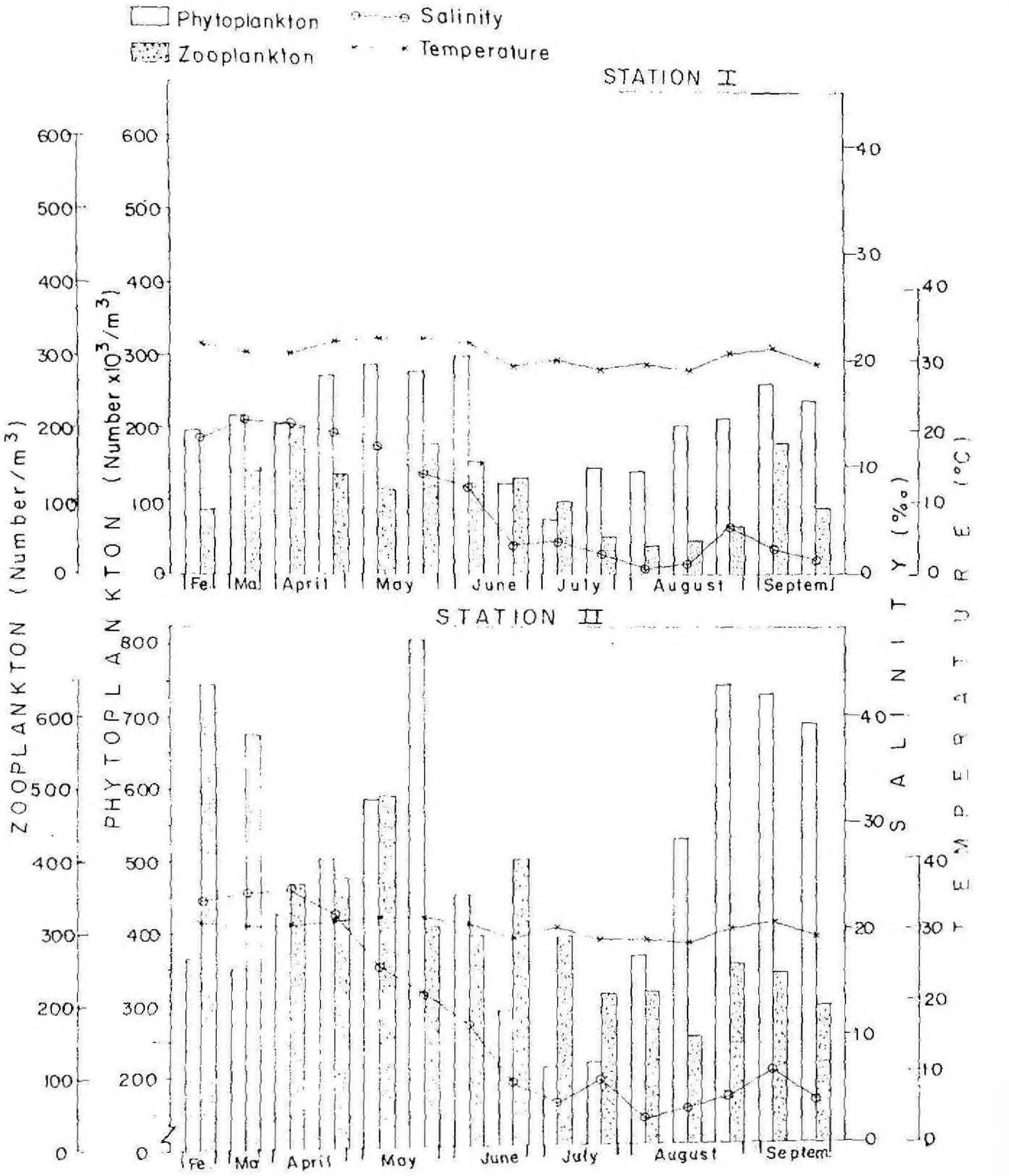
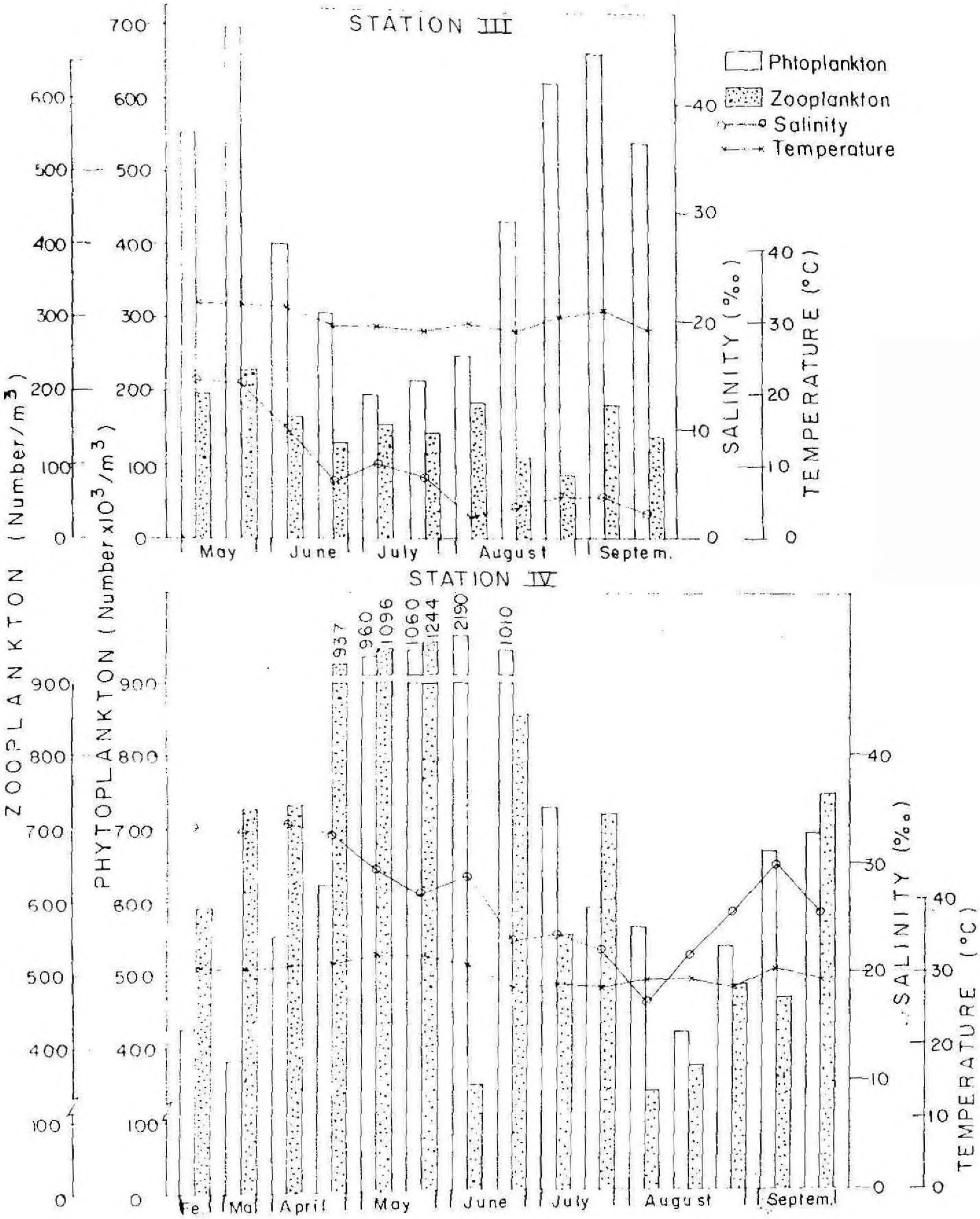

Phytoplankton
Zooplankton
Salinity
Temperature
STATION I
STATION II
ZOOPLANKTON (Number/m^3)
PHYTOPLANKTON (Number x10^3/m^3)
SALINITY (‰)
TEMPERATURE (°C)
Fe. Ma April May June July August Septem

Fig. 7 Histogram showing the variations in numerical abundance of phytoplankton and zooplankton in relation to temperature and salinity at station III during May to September, 1989.

Fig. 7 . Histogram showing the variations in numerical abundance of phytoplankton and zooplankton in relation to temperature and salinity at station IV during February to September, 1989.

Fig. 7



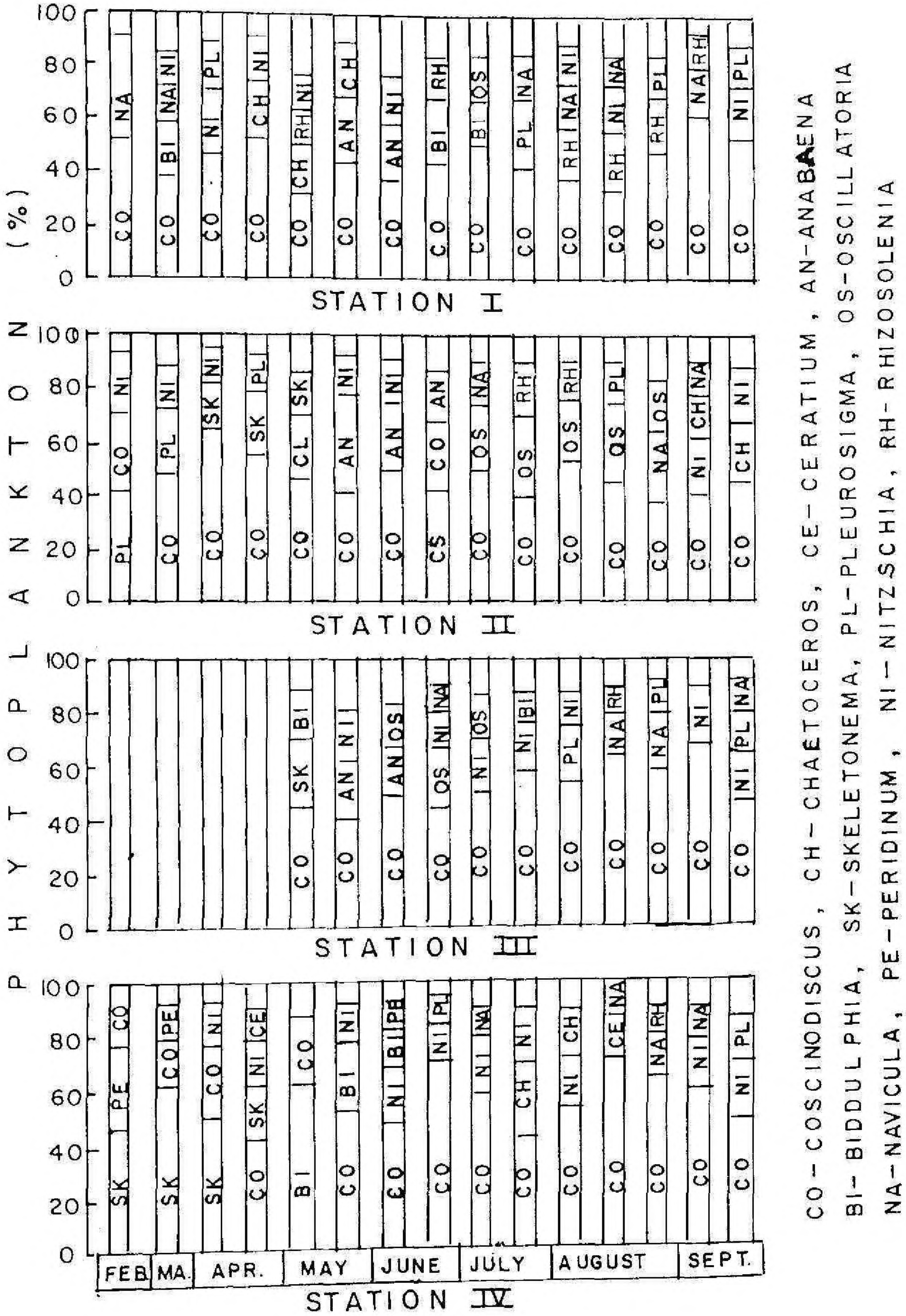
STATION III
Phtoplankton
Zooplankton
Salinity
Temperature
ZOOPLANKTON (Number/m³)
PHYTOPLANKTON (Number x10³/m³)
SALINITY (‰)
TEMPERATURE (°C)
May
June
July
August
Septem.
STATION IV
937
960
1096
1060
1244
2190
1010
Fe.
Mai
April
May
June
July
August
Septem.

TABLE 5: LIST OF IMPORTANT PHYTOPLANKTON SPECIES ENCOUNTERED AT STATION I - IV DURING FEBRUARY TO SEPTEMBER, 1989.

Diatoms:	
Amphora spp.	*Nitzschia closterium*
Asterionella japonica	*N. longissima*
Biddulphia mobiliensis	*N. seriata*
Chaetoceros affinis	*Pleurosigma normanii*
Chaetoceros spp.	*P. elongatum*
Coscinodiscus perforatus	*Rhizosolenia robosta*
C. radiatus	*Rhizosolenia* spp.
Coscinodiscus spp.	*Skeletonema costatum*
Fragilaria oceanica	*Suriella* spp.
Gyrosigma balticum	*Synedra* sp.
Navicula spp.	*Thalossionema* sp.
	Thalassiosira decipiens
Dinoflagellates:	
Ceratium furca	*Peridinium pentagonum*
Ceratium spp.	*P. claudicans*
Dinophysis spp.	*P. depressum*
	Peridinium spp.
Blue-green algae:	
Oscillatoria sp.	
Nostoc sp.	
Anabaena sp.	

Fig. 8. Histogram showing the percentage frequency of the major phytoplankton groups at station I-IV during February to September, 1989.

Fig. 8


PHYTOPLANKTON (%)
STATION I
STATION II
STATION III
STATION IV
FEB MA. APR. MAY JUNE JULY AUGUST SEPT.
CO-COSCINODISCUS, CH-CHAETOCEROS, CE-CERATIUM, AN-ANABAENA
BI-BIDDULPHIA, SK-SKELETONEMA, PL-PLEUROSIGMA, OS-OSCILLATORIA
NA-NAVICULA, PE-PERIDINUM, NI-NITZSCHIA, RH-RHIZOSOLENIA

at station IV, during premonsoon period, but were lesser in number during monsoon. The number of dinoflagellates was very low in all other stations,throughout the period of investigation.

4. ZOOPLANKTON

The variations in zooplankton distribution in four stations are given in table 6-9 (Fig. 6-7).

Quantitatively, the total number of zooplankton was found to be higher during premonsoon periods at all stations which showed a declining trend during monsoon season. It was observed that the abundance was maximum at station IV and minimum at station I throughout the period of study.

In station I, the maximum abundance of zooplankton was recorded in April, the number being 200/m^3. During the subsequent months the numerical abundance showed a gradual decline reaching to a minimum of 37 numbers/m^3 during August. However, during September zooplankton population registered a sharp increase.

Station II, with denser population of zooplankton also had higher concentration during premonsoon period, the maximum and minimum numbers of the population being 644/m^3 during February and 197/m^3 during August respectively.

Station III, observed only during May to September, had its zooplankton population ranging from 230 number/m^3 in May to 88 number/m^3 in August.

Station IV, with abundant population of zooplankton both in time and space, had the maximum concentration of 1244 number/m^3 in May and the minimum of 337 number/m^3 during August with a distinct peak during April-May months.

Qualitatively, the zooplankton population included ten major groups, such as: hydromedusae, polychaetes , cladocerans, copepods, amphipods, crab zoea, other decapod larvae, lucifer, fish egg and larvae and miscellaneous forms. The relative abundance of these forms are presented below: (Table 6-10;Fig.10)

4.1. Hydromedusae:

From the table, it could be seen that hydromedusae recorded only in station II and IV, were more during premonsoon period. In station IV, the maximum number of 382/m^3 was recorded during April while they were totally absent during monsoon in both the stations. The major species represented were Eirene spp. and Blackfordia spp. (Table 10).

4.2. Polychaetes:

Polychaete larvae and their adults belonging to the family Neridae were recorded in all the stations. Large numbers were recorded in station IV throughout the period. The number was found to be more during the monsoon period than during premonsoon season. Numbers as high was 680 / m^3 were obtained at station IV during the month of June. In other stations, they were sparsely distributed.

4.3. Cladocerans:

Cladocerans were observed in the plankton collection generally during monsoon months when the salinity of water was very low. Except in station IV, representing the intertidal zone, they were recorded in other three stations during June to August when the low salinity condition prevailed; with the maximum of 31 number/m^3 recorded in station III. Cladocerans in general were represented by Evadne tergestina and Penilia avirostris.

4.4. Copepods:

Among the zooplankton groups, copepods constituted the most dominant component in all four stations with a comparative predominance in station IV. Seasonally, they were abundant during April to June in station I, II and IV, the last station showing the maximum distribution of 597 number/m^3 during May. Major species encountered were Pseudodiaptomus spp. and Acartia spp. Besides these, large numbers of other species were also recorded (Table 10).

4.5. Amphipods:

Gammarid amphipods were represented in all the stations throughout the period of investigation. Higher concentration was noticed during premonsoonal period in station I and II, whereas in station IV maximum numbers were obtained during July-August period.

4.6. Crab zoea:

Larger number of brachiuran zoea were noticed in station II and IV during premonsoon period. These constituted the majority of the total counts of zooplankton during this period, with their total absence during monsoon months.

4.7. Other decapod larvae:

Post larvae of penaeid prawns formed the major component in this group. Caridean zoea also contributed to a considerable share. Represented in all the four stations under study, decapod larvae were dominant during the premonsoon periods. Numerically they were abundant in station II and IV.

4.8. Lucifer:

Few numbers of lucifer were noticed from station II and IV during the premonsoon periods, which were found to disappear from the plankton with the onset of monsoon.

TABLE 6 - VARIATIONS OF ZOOPLANKTON (NUMBER/M^3) AT STATION I DURING FEBRUARY TO SEPTEMBER, 1989.

	February	March	April		May		June		July		August			September	
Zooplankton groups	NM	FM	NM	FM	NM	FM	NM	FM	NM	FM	NM	FM	NM	FM	NM
Polychaetes	-	-	-	-	-	2	-	-	-	6	3	4	3	12	-
Cladocerans	-	-	-	-	-	6	27	23	9	12	-	4	8	-	-
Copepods	24	37	67	89	58	113	76	31	38	21	19	7	15	29	17
Amphipods	9	14	33	21	18	6	3	-	-	-	-	-	-	2	-
Crab zoea	7	24	8	-	-	-	-	-	-	-	-	-	-	-	-
Other decapod larvae	41	53	72	18	27	38	48	52	47	9	-	2	5	6	3
Lucifer	-	1	2	1	-	-	-	-	-	-	-	-	-	-	-
Fish egg and larvae	6	12	18	6	11	12	-	18	-	3	12	28	37	128	73
Miscellaneous	-	-	-	-	-	-	-	9	6	-	3	-	-	-	-
Total	84	141	200	135	114	177	154	133	100	51	37	45	68	177	93

FM - Full moon, NM - New moon

TABLE 7 - VARIATIONS OF ZOOPLANKTON (NUMBER/M^3) AT STATION II DURING FEBRUARY TO SEPTEMBER, 1989.

	February	March	April		May		June		July		August			September	
Zooplankton groups	NM	FM	NM	FM	NM	FM	NM	FM	NM	FM	NM	FM	NM	FM	NM
Hydromedusae	32	18	24	16	-	-	-	-	-	-	-	-	-	-	-
Polychaetes	-	-	-	-	17	2	-	-	4	17	-	-	7	3	8
Cladocerans	-	-	-	-	-	-	4	12	23	6	12	4	-	2	-
Copepods	78	82	121	177	249	129	167	243	210	91	114	86	189	127	122
Amphipods	14	12	23	11	18	6	-	-	-	2	11	4	-	-	-
Crab zoea	408	286	56	48	21	-	-	-	-	-	-	-	-	-	-
Other decapod larvae	105	162	123	106	173	167	98	126	32	71	34	28	22	43	24
Lucifer	4	7	6	1	2	2	-	-	-	-	-	-	-	-	-
Fish egg and larvae	3	7	14	15	7	-	24	18	17	7	33	25	32	63	37
Miscellaneous	-	-	-	-	-	-	-	-	4	17	9	-	-	-	-
Total	644	574	367	374	487	306	293	399	290	211	213	147	250	238	191

FM - Full moon, NM - New moon

TABLE 8 - VARIATIONS OF ZOOPLANKTON (NUMBER/M^3) AT STATION III DURING MAY TO SEPTEMBER, 1989

	May		June		July			August		September	
Zooplankton groups	NM	FM	NM	FM	NM	FM	NM	FM	NM	FM	NM
Polychaetes	-	3	2	-	-	-	1	-	3	9	23
Cladocerans	-	-	-	3	26	31	10	2	9	-	-
Copepods	96	112	85	57	47	46	96	57	21	41	53
Amphipods	7	6	-	-	-	3	27	6	14	3	-
Other decapod larvae	81	97	71	42	57	27	32	18	10	16	6
Fish egg and larvae	12	12	7	26	18	21	19	29	27	116	57
Miscell aneous	-	-	-	1	6	16	2	-	4	-	-
Total	196	230	165	129	154	144	187	112	88	185	139

FM - Full moon, NM - New moon

TABLE 9 - VARIATIONS OF ZOOPLANKTON (NUMBER/M^3) AT STATION IV DURING FEBRUARY TO SEPTEMBER, 1989.

	February	March	April		May		June		July		August		September		
Zooplankton groups	NM	FM	NM	FM	NM	FM	NM	FM	NM	FM	NM	FM	NM	FM	NM
Hydromedusae	176	218	382	117	112	16	86	-	-	-	-	-	-	-	-
Polychaetes	-	18	67	94	427	86	59	680	423	460	98	127	298	218	457
Copepods	83	97	92	376	262	597	178	46	28	98	37	42	66	74	26
Amphipods	1	11	6	7	12	-	-	-	23	14	18	24	27	12	3
Crab zoea	268	312	91	7	-	-	-	-	-	-	-	-	-	-	-
Other decapod larvae	42	74	76	308	276	489	89	127	72	118	97	126	38	17	12
Lucifer	12	3	5	-	4	-	-	-	-	-	-	-	-	-	-
Fish egg and larvae	8	19	12	28	14	56	18	2	6	27	87	51	54	145	246
Total	590	752	733	937	1096	1244	350	855	552	717	337	370	483	456	744

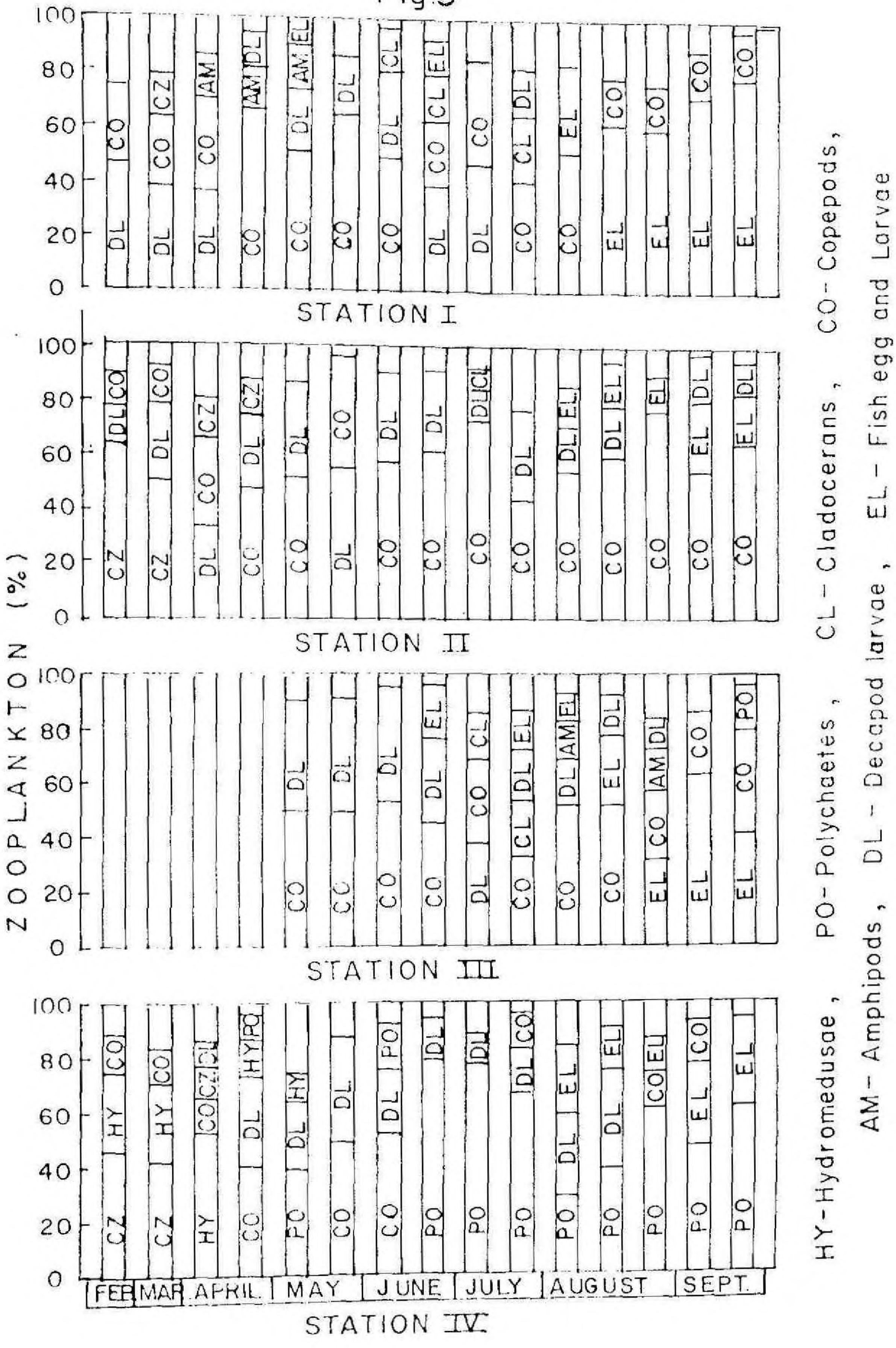
FM - Full moon, NM - New moon.

TABLE 10. LIST OF IMPORTANT ZOOPLANKTON SPECIES ENCOUNTERED AT STATION I - IV, DURING FEBRUARY TO SEPTEMBER, 1989

Hydromedusae:	
Blackfordia virginica	Eutima commensalis
Eirene cylonensis	
Polychaetes:	
Corophium triaenonyx	Polychaete larvae
Photis longicaudata	
Cladocerans:	
Evadne tergestina	
Penilia avirostris	
Copepods:	
Pseudodiaptomus serricaudatus	Paracalanus aculeatus
P. annandalei	P. crassirostris
Labidocera pectinata	Heliodiaptomus cinctus
Acartia contrura	Allodiaptomus mirabilipes
A. spinicauda	Acrocalcanus similis
A. plumosa	Oithona spp.
A. bilobata	
Amphipods:	
Gammarid amphipods	
Decapod larvae:	
Brachyuran zoea	Caridean zoea.
Post larvae of penaeid prawn	
Lucifer:	
Lucifer hanseni	
Fish egg and larvae:	
Ambassis gymnocephalus	Fish eggs
Gobids	
Miscellaneous group:	
Rotifers	Cumaceans
Mysids	Cerriped larvae.

Fig. 9. Histogram showing the percentage frequency of the major zooplankton groups at station I-IV during February to September, 1989.

Fig.9


ZOOPLANKTON (%)
STATION I
STATION II
STATION III
STATION IV
FEB MAR APRIL MAY JUNE JULY AUGUST SEPT.
HY-Hydromedusae, PO-Polychaetes, CL-Cladocerans, CO-Copepods,
AM-Amphipods, DL-Decapod larvae, EL-Fish egg and Larvae

4.9. Fish egg and larvae:

The fish egg and larvae were found distributed throughout the study period in all the four stations, their occurrence being more during August-September in all the stations. During the above period, larvae of Ambassis gymnocephalus were obtained in good quantities from Station I, II and III, whereas in station IV the group was represented mainly by fish eggs.

4.10. Miscellaneous group:

Many other groups such as rotifers, cirriped larvae, mysids and cumaceans were represented in this group in all the stations except in station IV.

5. DISTRIBUTION AND ABUNDANCE OF FRY:

The variations in total abundance of fry and relative abundance of different species are given in Table 11-14 (Fig. 13).

During the present investigation, the fry of cultivable fishes were represented by five species such as Liza parsia, L. macrolepis, Mugil cephalus, Chanos chanos and Megalops cyprinoides, (Plate V - VII)

In station I, fry of only L. parsia and L. macrolepis were encoutered. They had their distribution mainly during the premonsoon period, with a few number of L. parsia occurring during August also.

With more species of cultivable fish fry distributed, station II had L. parsia and L. macrolepis, recorded throughout the period of investigation. Other species noticed seasonally were M. cephalus, M. cyprinoides and C. chanos.

In station III, species such as L. parsia and L. macrolepis were distributed throughout the study period, but were in lesser quantities during the months May to July. M. cephalus was obtained only during the month of July and during first fortnight of August, while M. cyprinoides was recorded mainly during May.

Similarising station I, L. parsia and L. macrolepis were distributed in station IV during premonsoon period only, with a few numbers of L. parsia occurring during later half of the study period also. However, unlike in station I, other species like M. cephalus, M. cyprinoides and C. chanos were also encountered in station IV.

A scrutiny of the seasonal abundance of fry of different species indicated that the total number of fry obtained per unit effort was maximum during the premonsoon and early monsoon in station II, III and IV. The number was found to be decreasing to a considerable extent during the months of August and September. But in station I, the fry were obtained in a larger number during February-May and in lesser number during August-September.

Among the five species of fry of cultivable fishes obtained, L. parsia was the most dominant species, caught in all the four stations throughout the period of study. L. macrolepis, the next dominant species was also found to have the similar pattern of distribution as L. parsia, but with lesser abundance.

The fry of M. cephalus was recorded only during June to August with a peak during July. It was obtained from all the four stations except station I. A maximum of 46 number/ unit effort was observed in station II during July.

The fry of C. chanos was observed during March-April only from station II and IV. A maximum number of 22/ unit effort was obtained in station II during March.

The leptocephalus larvae of M. cyprinoides formed one among the dominant groups caught during February to June in station II and IV. It was abundant during the premonsoon period with a peak during April-May. Their number was found greatly reduced during monsoon with their total absence during September in all the stations. The species was not observed in station I, during the period of study. In station II, a maximum of 66 number/unit effort was caught during April.

TABLE 11 - ABUNDANCE OF FRY OF CULTIVABLE FISHES (NUMBER/UNIT EFFORT) AT STATION I DURING FEBRUARY TO SEPTEMBER 1989.

Species	February	March	April		May		June		July			August		September	
	NM	FM	NM	FM	NM	FM	NM	FM	NM	FM	NM	FM	NM	FM	NM
Liza parsia	32	52	24	7	11	-	-	-	-	-	-	7	6	3	-
L. macrolepis.	18	7	9	-	4	-	-	-	-	-	-	-	-	-	-
Total	50	59	33	7	15	-	-	-	-	-	-	7	6	3	-

FM - Full moon, NM - New moon.

TABLE 12 - ABUNDANCE OF FRY OF CULTIVABLE FISHES (NUMBER/UNIT EFFORT) AT STATION II DURING FEBRUARY TO SEPTEMBER 1989.

Species	February	March	April		May		June		July		August		September		
	NM	FM	NM	FM	NM	FM	NM	FM	NM	FM	NM	FM	NM	FM	NM
Liza parsia	46	47	38	44	69	28	27	18	34	64	32	37	24	18	27
L. macrolepis	9	4	5	2	17	2	6	5	-	4	7	4	3	2	6
Mugil cephalus	-	-	-	-	-	-	7	14	22	27	18	8	3	-	-
Megalops cyprinoides	12	26	66	48	42	24	8	-	-	6	4	-	-	-	-
Chanos chanos	-	22	17	3	-	-	-	-	-	-	-	-	-	-	-
Total	67	99	126	97	128	54	48	37	56	101	61	49	30	20	33

FM - Full moon, NM - New moon

TABLE 13 - ABUNDANCE OF FRY OF CULTIVABLE FISHES (NUMBER/UNIT EFFORT) AT STATION III DURING MAY TO SEPTEMBER 1989.

Species	May		June		July			August		September	
	NM	FM	NM	FM	NM	FM	NM	FM	NM	FM	NM
Liza parsia	62	47	42	22	41	122	38	23	18	37	12
L. macrolepis	19	12	3	4	16	29	5	7	6	9	4
Mugil cephalus	-	-	-	-	18	46	10	-	-	-	-
Megalops cyprinoides	24	22	3	-	-	-	4	-	-	-	-
Total	105	81	48	26	75	197	57	30	24	46	16

FM - Full moon, NM - New moon

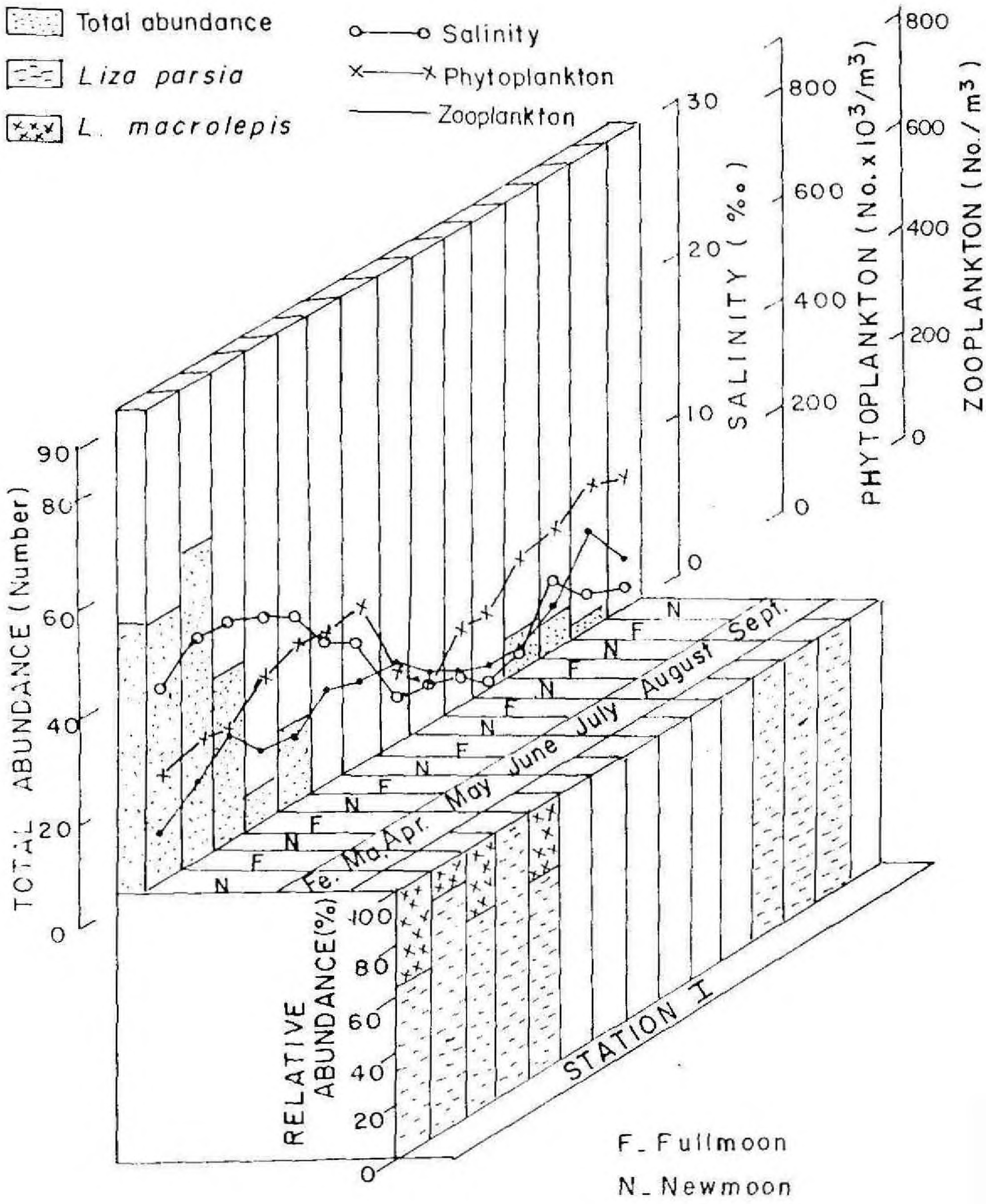
TABLE 14 - ABUNDANCE OF FRY OF CULTIVABLE FISHES (NUMBER/UNIT EFFORT) AT STATION IV DURING FEBRUARY TO SEPTEMBER 1989.

Species	February	March	April		May		June		July			August		September	
	NM	FM	NM	FM	NM	FM	NM	FM	NM	FM	NM	FM	NM	FM	NM
Liza parsia	34	22	12	19	17	9	-	-	3	-	6	-	6	7	2
L. macrolepis	12	7	-	4	2	-	-	-	-	-	-	-	-	-	-
Mugil cephalus	-	-	-	-	-	-	-	-	12	7	-	-	-	-	-
Megalops cyprinoides	-	27	34	18	22	21	7	-	2	12	3	-	-	-	-
Chanos chanos	-	7	4	-	-	-	-	-	-	-	-	-	-	-	-
Total	46	63	50	41	41	30	7	-	17	19	9	-	6	7	2

FM - Full moon, NM - New moon

Fig. 10. Variations in abundance of fry in relation to salinity, *phytoplankton and zooplankton at station I during* February to September, 1989.

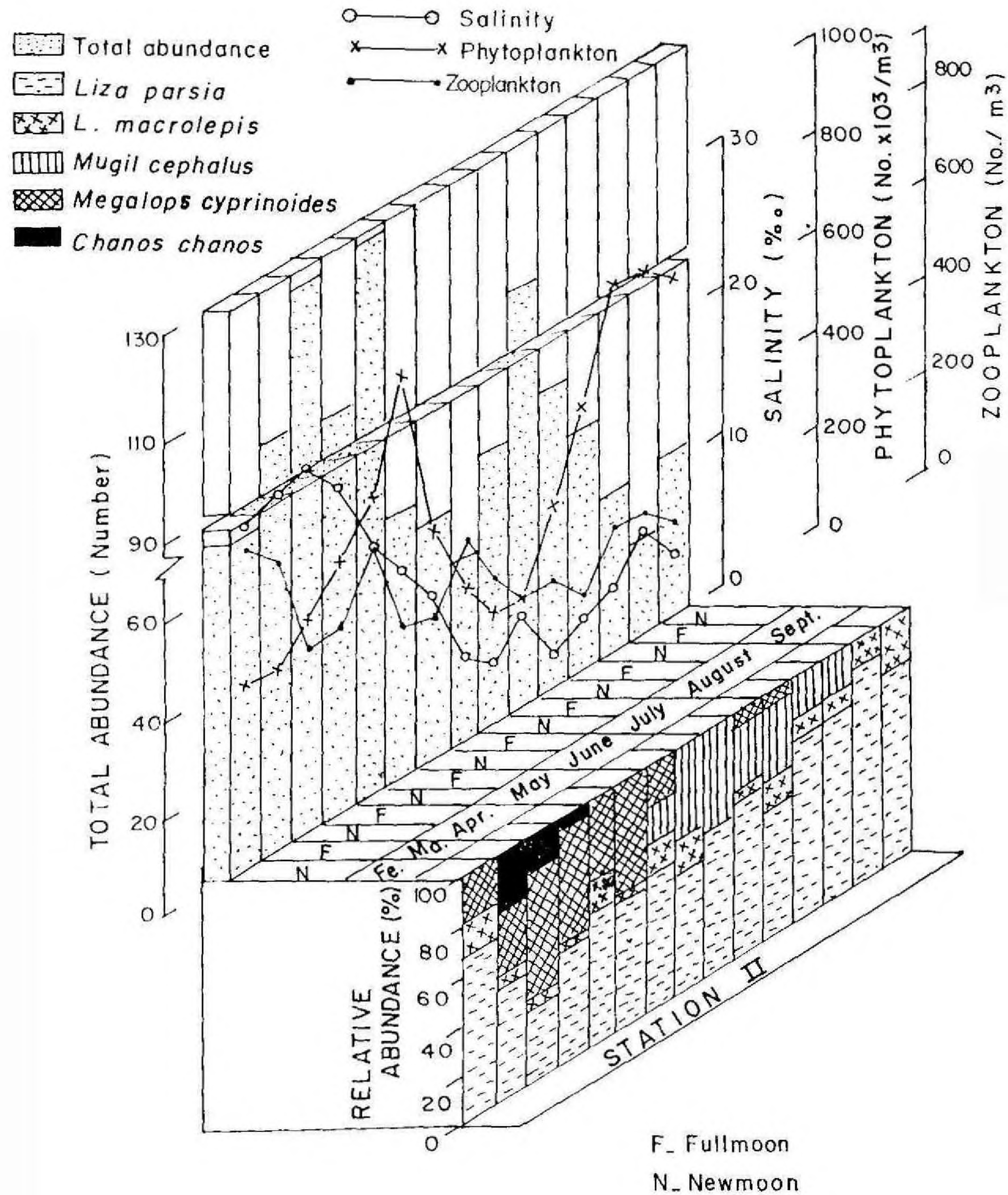
Fig. 10



Total abundance
Liza parsia
L. macrolepis
Salinity
Phytoplankton
Zooplankton
TOTAL ABUNDANCE (Number)
0
20
40
60
80
90
SALINITY (‰)
0
10
20
30
PHYTOPLANKTON (No. x 10^3/m^3)
0
200
400
600
800
ZOOPLANKTON (No./m^3)
0
200
400
600
800
Fe.
Ma.
Apr.
May
June
July
August
Sept.
N
F
RELATIVE ABUNDANCE(%)
0
20
40
60
80
100
STATION I
F_Fullmoon
N_Newmoon

Fig. 11. Variations in abundance of fry in relation to salinity, phytoplankton and zooplankton at station II during February to September, 1989.

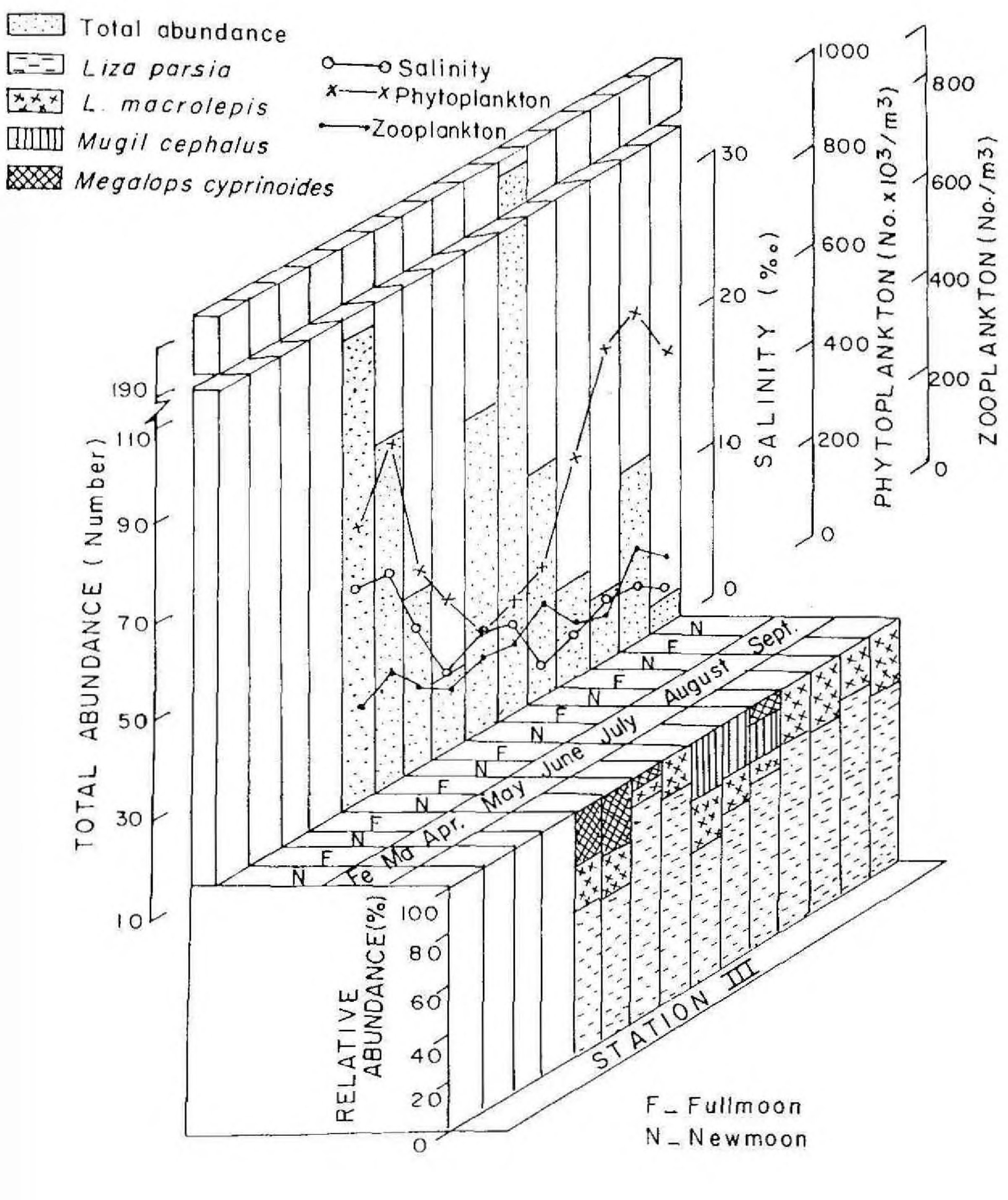
Fig. 11



Total abundance
Liza parsia
L. macrolepis
Mugil cephalus
Megalops cyprinoides
Chanos chanos
Salinity
Phytoplankton
Zooplankton
TOTAL ABUNDANCE (Number)
SALINITY (‰)
PHYTOPLANKTON (No. x10³/m3)
ZOOPLANKTON (No./ m3)
RELATIVE ABUNDANCE (%)
Fe. Ma. Apr. May June July August Sept.
STATION II
F_ Fullmoon
N_ Newmoon

Fig. 12. Variations in abundance of fry in relation to salinity, phytoplankton and zooplankton at station III during May to September, 1989.

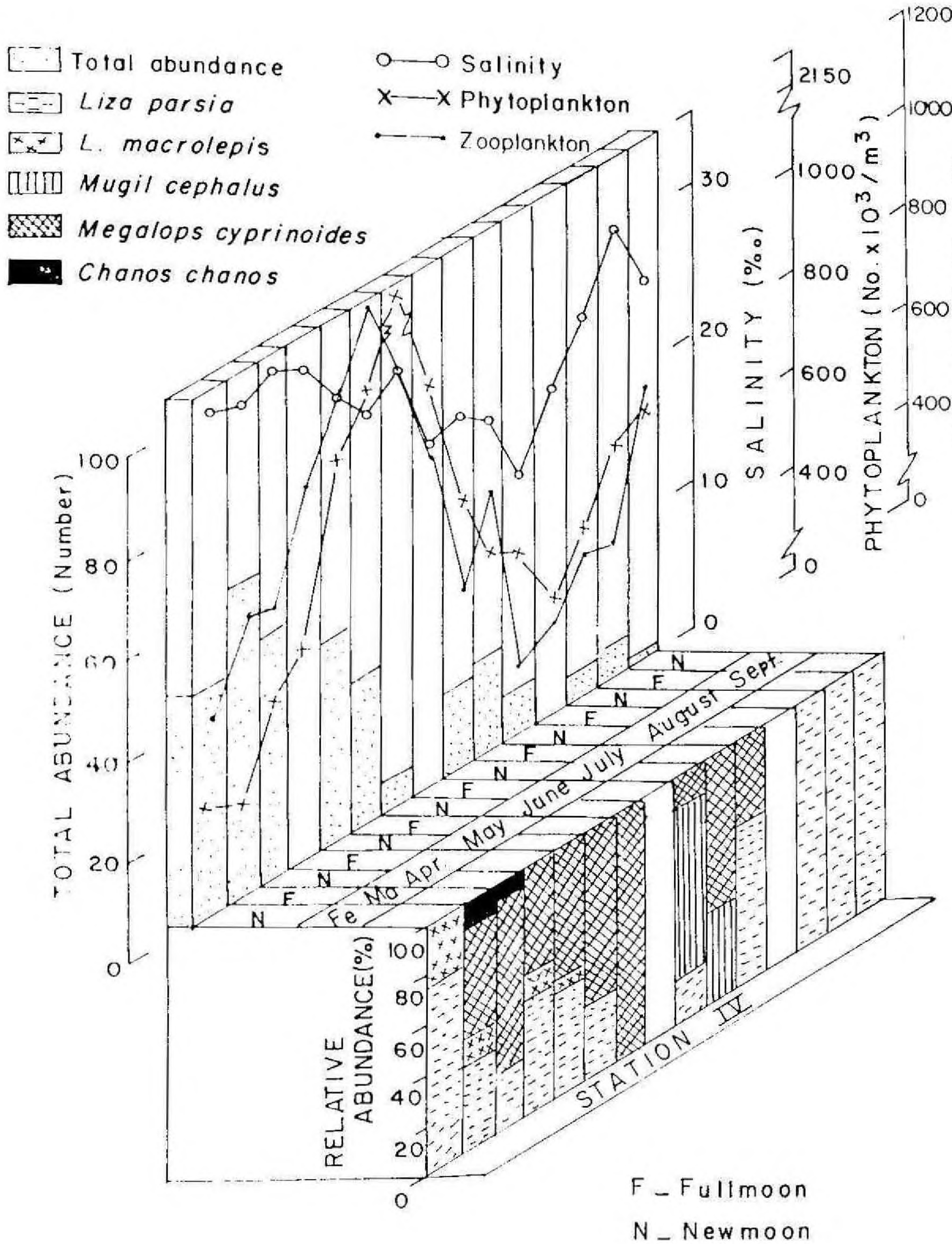
Fig. 12



Total abundance
Liza parsia
L. macrolepis
Mugil cephalus
Megalops cyprinoides
Salinity
Phytoplankton
Zooplankton
TOTAL ABUNDANCE (Number)
190
110
90
70
50
30
10
SALINITY (‰)
30
20
10
0
PHYTOPLANKTON (No. x 10³/m³)
1000
800
600
400
200
0
ZOOPLANKTON (No./m³)
800
600
400
200
0
N F Fe Ma Apr. May June July August Sept.
RELATIVE ABUNDANCE (%)
100
80
60
40
20
0
STATION III
F _ Fullmoon
N _ Newmoon

Fig. 13. *Variations in abundance of fry in relation to salinity,* phytoplankton and zooplankton at station IV during February to September, 1989.

Fig. 13



Total abundance
Liza parsia
L. macrolepis
Mugil cephalus
Megalops cyprinoides
Chanos chanos
Salinity
Phytoplankton
Zooplankton
TOTAL ABUNDANCE (Number)
SALINITY (‰)
PHYTOPLANKTON (No. x 10^3 / m^3)
ZOOPLANKTON (No. / m^3)
RELATIVE ABUNDANCE (%)
Fe Ma Apr. May June July August Sept.
STATION IV
F _ Fullmoon
N _ Newmoon

Fig. 14. Graph showing the overall size range and dominant size of fry at station I–IV.

Fig. 14i. Graph showing the overall size range and dominant size of juveniles at station I–IV.

Fig. 14

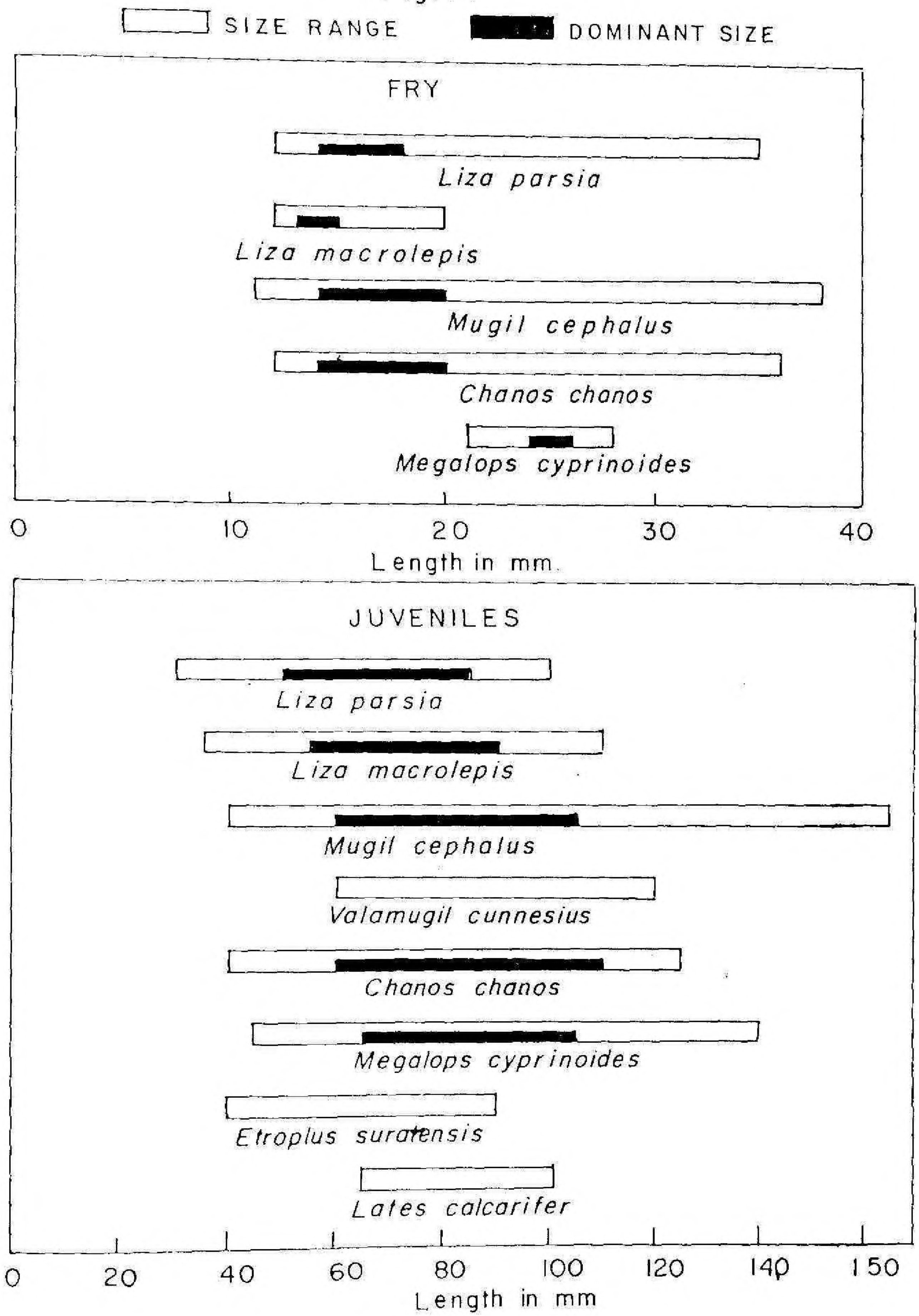

SIZE RANGE
DOMINANT SIZE
FRY
Liza parsia
Liza macrolepis
Mugil cephalus
Chanos chanos
Megalops cyprinoides
0
10
20
30
40
Length in mm.
JUVENILES
Liza parsia
Liza macrolepis
Mugil cephalus
Valamugil cunnesius
Chanos chanos
Megalops cyprinoides
Etroplus suratensis
Lates calcarifer
0
20
40
60
80
100
120
140
150
Length in mm

PLATE V: Photograph showing the fry of (A) *Liza parsia* (B) *Mugil cephalus.*

PLATE VI: Photograph showing the fry of *Chanos chanos.*

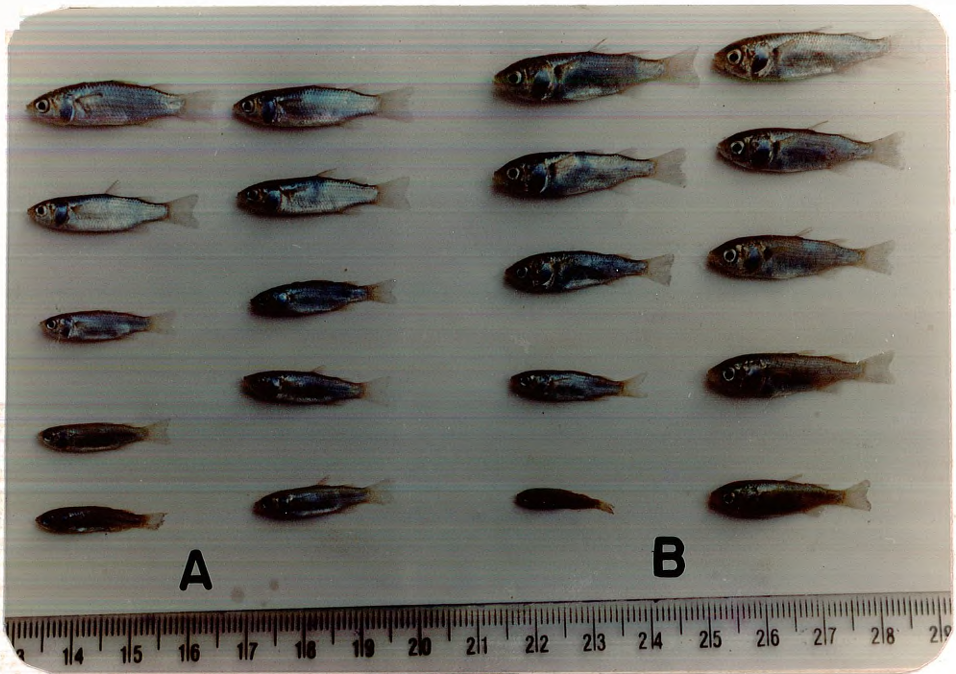


PLATE V

PLATE VI

PLATE VII: Photograph showing the larvae of <u>Megalops</u> <u>cyprinoides.</u>

PLATE VIII: Photograph showing the juveniles of (A) <u>Mugil</u> <u>cephalus</u> (B) <u>liza</u> <u>parsia.</u>

PLATE VII

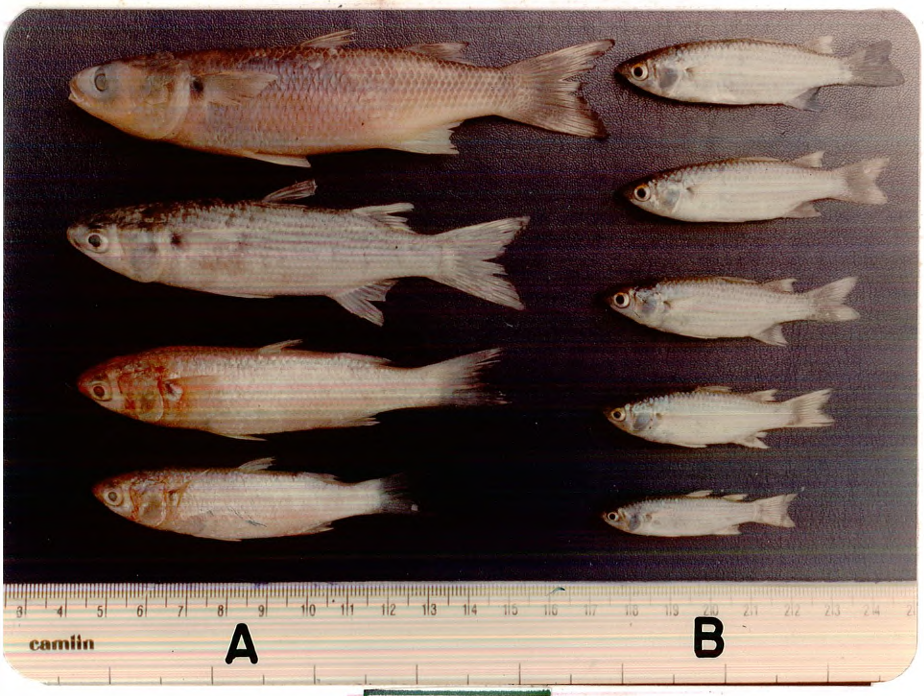


PLATE VIII

PLATE IX: Photograph showing the juveniles of (A) Chanos chanos (B) Megalops cyprinoides.

PLATE X: Photograph showing the juveniles of (A)Lates calcarifer (B) Etroplus suratensis.

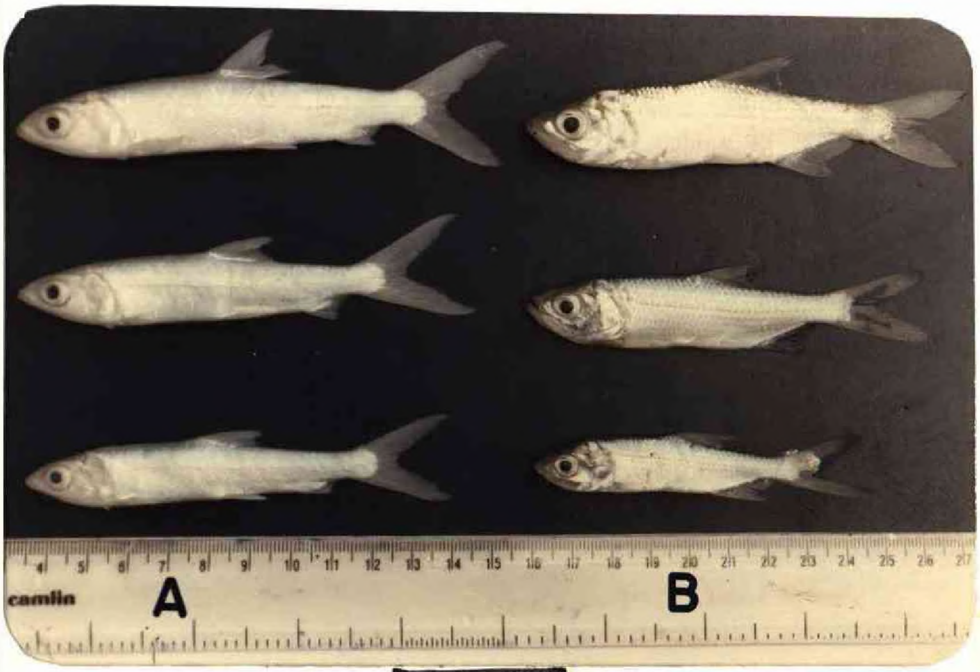


PLATE IX

PLATE X

The overall size distribution of the fry of different species caught is given in Fig. 14.

It is noticeable that, the size of L. parsia ranged between 12-35 mm, with the modal size 14-18 mm and the size of L. macrolepis was ranging between 12-20 mm with the modal size 13-15 mm. The fry of M. cephalus obtained was ranging in size between 11-38 mm with the dominant length range of 12-16mm. The fry of C. chanos obtained ranged in size between 12-35 mm out of which the size of 14-18 mm were abundant in number constituting more than 80% of the total milk fish fry caught. The leaf like leptocephalus larvae of M. cyprinoides ranged in size between 21-28 mm, with the modal size of 24-26 mm.

6. DISTRIBUTION AND ABUNDANCE OF JUVENILES:

The variations in abundance of juveniles observed in four stations and the relative abundance of different species are given in table 15-18 (Fig. 15-18).

Distribution of juveniles in time and space showed that they occur more during the premonsoon period especially in station I, II and III. Station IV with comparatively sparse distribution had the seed available only upto July. Among the different stations, station II was richer in abundance of juveniles followed by station III. The maximum number of juveniles recorded was 26/unit effort in station II during April.

During the present investigation, juveniles of nine species of cultivable finfishes were recorded. L. parsia was the major species caught throughout the year in all the stations, followed by L. macrolepis, both together constituting more than 90% of the total catch.

Few numbers of Valamugil cunnesius were recorded in station I, II and III during monsoon seasons. Juveniles of M. cephalus, C. chanos and M. cyprinoides were obtained in fewer numbers only after the onset of monsoon in station II and III. In station IV, only four numbers of juveniles of C. chanos were caught during June-July months. It was interesting to note that none of these species was recorded at Station I, during the study period.

Juveniles of pearl spot, Etroplus suratensis were obtained occasionally from station II and III in fewer numbers. Only two juveniles of Lates calcarifer were recorded throughout the period of investigation from station II, one each during month of July and August.

The overall size range and the dominant size of juveniles of different species are given in figure 14; Plate VIII - X .

TABLE 15 - ABUNDANCE OF JUVENILES OF CULTIVABLE FISHES (NUMBER/UNIT EFFORT) AT STATION I DURING FEBRUARY TO SEPTEMBER 1989.

Species	February	March	April		May		June		July		August			September	
	NM	FM	NM	FM	NM	FM	NM	FM	NM	FM	NM	FM	NM	FM	NM
Liza parsia	4	9	14	3	7	2	2	1	-	2	1	6	7	14	6
L. macrolepis	1	-	3	-	1	-	1	1	-	-	-	2	1	2	1
Valamugil cunnesius	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
Total	5	9	17	3	8	2	3	2	-	2	1	10	8	17	7

FM - Full moon, NM - New moon

TABLE 16 - ABUNDANCE OF JUVENILES OF CULTIVABLE FISHES (NUMBER/UNIT EFFORT) AT STATION II DURING FEBRUARY TO SEPTEMBER 1989.

Species	February	March	April		May		June		July		August			September	
	NM	FM	NM	FM	NM	FM	NM	FM	NM	FM	NM	FM	NM	FM	NM
Liza parsia	12	21	18	20	23	14	12	7	14	8	9	12	6	12	14
L. macrolepis	2	3	5	6	2	4	4	-	2	-	2	1	2	2	4
Valamugil connesius	-	-	-	-	-	-	-	-	-	-	1	-	1	-	-
Mugil cephalus	-	-	-	-	-	-	-	-	-	-	1	2	1	1	-
Chanos chanos	-	-	-	-	-	-	-	2	1	1	-	2	1	-	-
Megalops cyprinoides	-	-	-	-	-	-	-	-	1	-	-	1	1	1	-
Etroplus suratensis	-	1	-	-	-	-	-	-	-	1	-	-	-	1	1
Lates calcarifer	-	-	-	-	-	-	-	-	-	1	-	1	-	-	-
Total	14	25	23	26	25	18	16	9	18	11	13	19	12	17	19

FM - Full moon, NM - New moon

TABLE 17 - ABUNDANCE OF JUVENILES OF CULTIVABLE FISHES (NUMBER/UNIT EFFORT) AT STATION III DURING MAY TO SEPTEMBER 1989.

Species	May		June		July			August		September	
	NM	FM	NM	FM	NM	FM	NM	FM	NM	FM	NM
Liza parsia	17	11	18	8	6	5	12	10	9	14	7
L. macrolepis	6	2	2	1	3	1	3	1	2	2	3
Valamugil cunnesius	-	-	-	-	-	-	-	1	1	-	-
Mugil cephalus	-	-	-	-	-	1	-	2	1	-	-
Chanos chanos	-	-	-	-	-	-	-	1	-	1	-
Megalops cyprinoides	-	-	-	1	-	-	1	1	2	-	-
Etroplus suratensis	-	-	-	-	-	-	1	-	-	1	-
Total	23	13	20	10	9	7	17	16	15	18	10

FM - Full moon, NM - New moon.

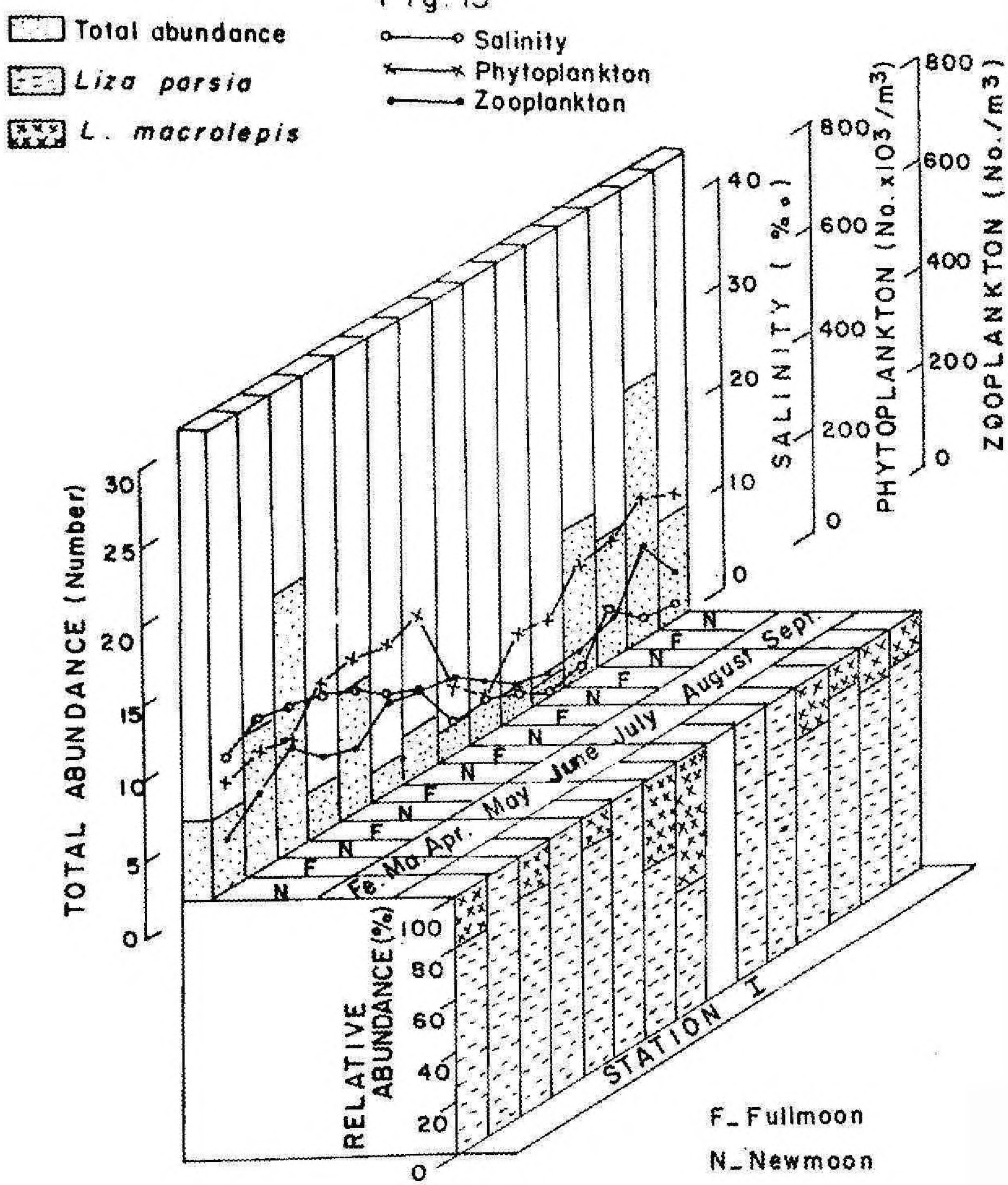
TABLE 18 - ABUNDANCE OF JUVENILES OF CULTIVABLE FISHES (NUMBER/UNIT EFFORT) AT STATION IV DURING FEBRUARY TO SEPTEMBER 1989.

Species	February	March	April		May		June		July		August		September		
	NM	FM	NM	FM	NM	FM	NM	FM	NM	FM	NM	FM	NM	FM	NM
Liza parsia	4	2	3	-	-	1	2	2	-	-	-	-	-	-	-
L. macrolepis	-	1	-	-	-	-	1	-	-	-	-	-	-	-	-
Canos chanos	-	-	-	-	-	-	1	1	2	-	-	-	-	-	-
Total	4	3	3	-	-	1	4	3	2	-	-	-	-	-	-

FM - Full moon, NM - New moon

Fig. 15. Variations in abundance of juveniles in relation to salinity, phytoplankton and zooplankton at station I during February to September, 1989.

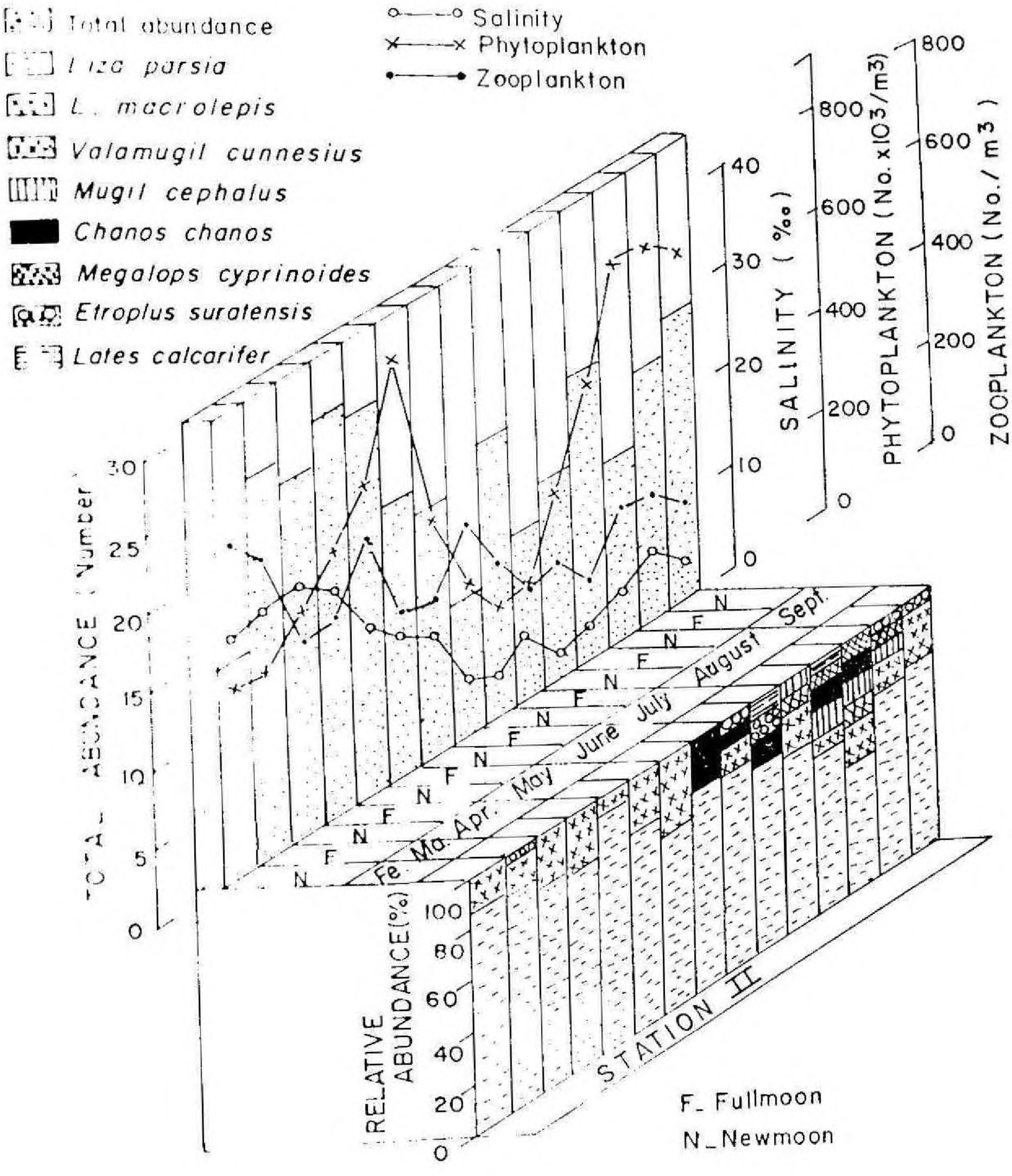
Fig. 15



Total abundance
Liza parsia
L. macrolepis
Salinity
Phytoplankton
Zooplankton
TOTAL ABUNDANCE (Number)
0
5
10
15
20
25
30
SALINITY (‰)
0
10
20
30
40
PHYTOPLANKTON (No. x10³/m³)
0
200
400
600
800
ZOOPLANKTON (No./m³)
0
200
400
600
800
N
F
Fe.
Ma.
Apr.
May
June
July
August
Sept.
RELATIVE ABUNDANCE (%)
0
20
40
60
80
100
STATION I
F_ Fullmoon
N_ Newmoon

Fig. 16. Variations in abundance of juveniles in relation to salinity, phytoplankton and zooplankton at station II during February to September, 1989.

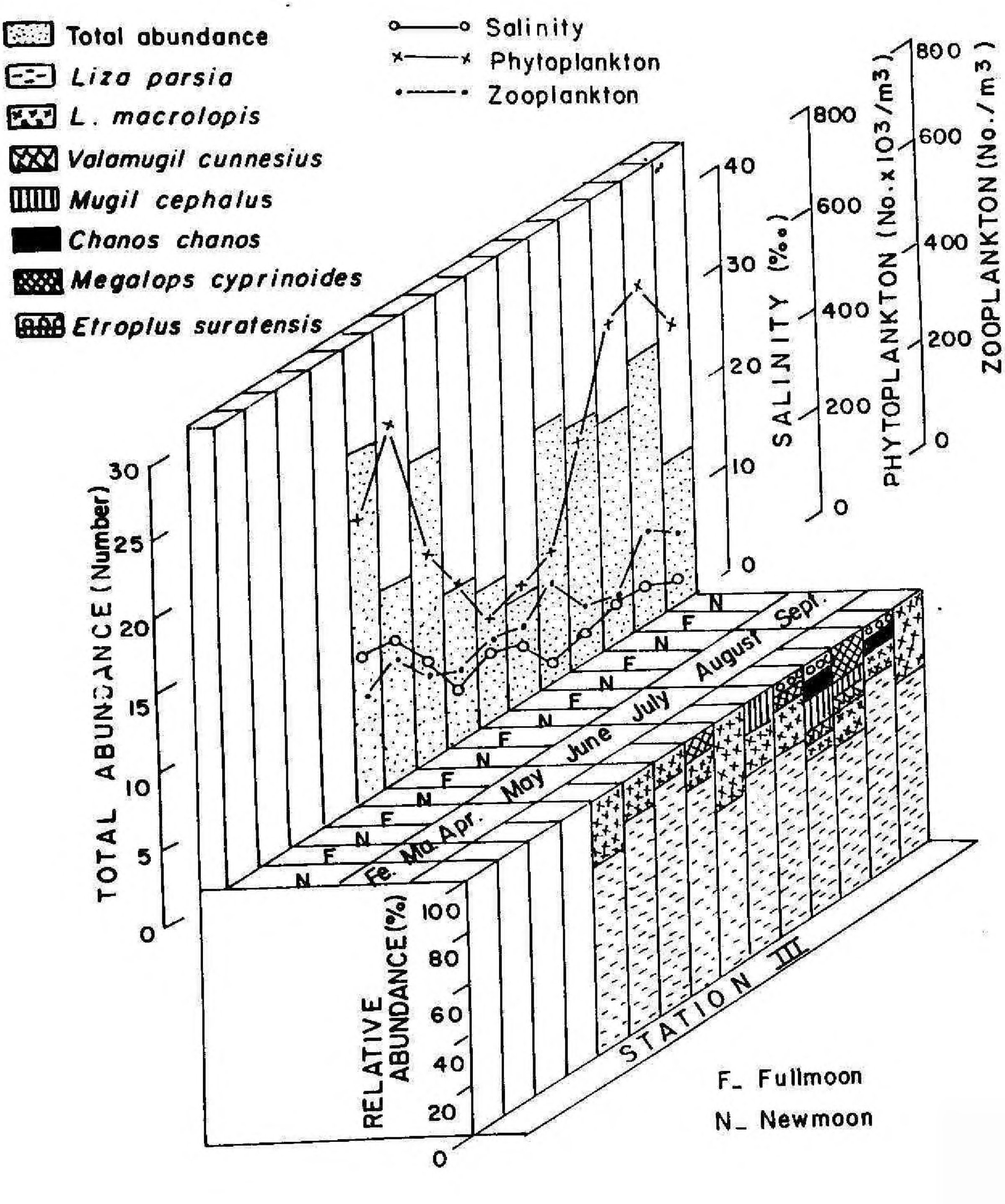
Fig. 16



Total abundance
Liza parsia
L. macrolepis
Valamugil cunnesius
Mugil cephalus
Chanos chanos
Megalops cyprinoides
Etroplus suratensis
Lates calcarifer
Salinity
Phytoplankton
Zooplankton
SALINITY (‰)
PHYTOPLANKTON (No. x103/m3)
ZOOPLANKTON (No./m3)
TOTAL ABUNDANCE (Number)
RELATIVE ABUNDANCE (%)
Fe
Ma.
Apr.
May
June
July
August
Sept.
STATION II
F_ Fullmoon
N_ Newmoon

Fig. 17. Variations in abundance of juveniles in relation to salinity, phytoplankton and zooplankton at station III during May to September, 1989.

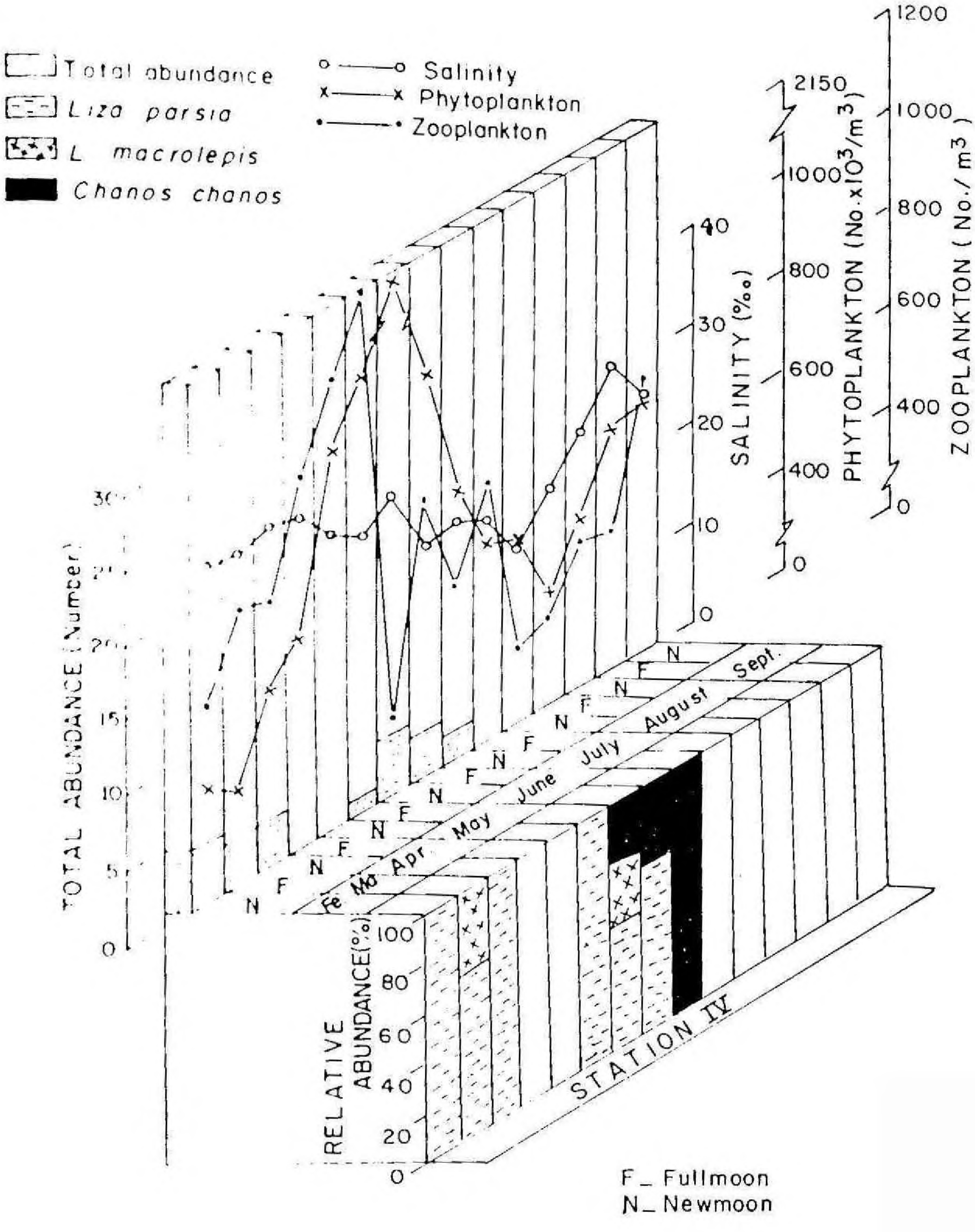
Fig. 17



Total abundance
Liza parsia
L. macrolopis
Valamugil cunnesius
Mugil cephalus
Chanos chanos
Megalops cyprinoides
Etroplus suratensis
Salinity
Phytoplankton
Zooplankton
TOTAL ABUNDANCE (Number)
0
5
10
15
20
25
30
SALINITY (‰)
0
10
20
30
40
PHYTOPLANKTON (No. x 103/m3)
0
200
400
600
800
ZOOPLANKTON (No./m3)
0
200
400
600
800
RELATIVE ABUNDANCE (%)
0
20
40
60
80
100
N
F
Fe.
Ma.
Apr.
May
June
July
August
Sept.
STATION III
F_ Fullmoon
N_ Newmoon

Fig. 18. Variations in abundance of juveniles in relation to salinity, phytoplankton and zooplankton at station IV during February to September, 1989.

Fig. 18



Total abundance
Liza parsia
L macrolepis
Chanos chanos
Salinity
Phytoplankton
Zooplankton
TOTAL ABUNDANCE (Number)
SALINITY (‰)
PHYTOPLANKTON (No.x10^3/m^3)
ZOOPLANKTON (No./m^3)
2150
1000
800
600
400
0
1200
1000
800
600
400
0
40
30
20
10
0
RELATIVE ABUNDANCE(%)
100
80
60
40
20
0
Fe
Mo
Apr
May
June
July
August
Sept.
STATION IV
F _ Fullmoon
N _ Newmoon

The size of L. parsia obtained varied between 30-100 mm with the modal size 60-90 mm.

The size of L. macrolepis ranged between 30-110 mm with the dominant length range of 55-90 mm. A few numbers of V. cunnesius recorded were within the size range of 60-120 mm. A size range of 40-155 mm with the dominant size of 60-105 mm was recorded in case of M. cephalus. With a modal size of 65-105 mm, C. chanos was within the size range of 45-140 mm. M. cyprinoides which was recorded in a fewer numbers during the study period, was within the size range of 40-125 mm with the dominant size of 60-110 mm. The size of E. suratensis and L. calcarifer ranged between 40-90mm and 65-100 mm respectively.

7. DIURNAL INFLUENCE OF HYDROBIOLOGICAL FACTORS ON THE ABUNDANCE OF FRY AND JUVENILES:

In view of the comparative abundance of fry and juveniles at station II and III, diurnal observations were made in these stations, depending on the tides. The studies were made at every three hours interval with a view to correlate the diurnal abundance of fry and juveniles of fishes and the environmental parameters, such as tide, time of collection, water temperature, salinity, dissolved oxygen, pH, dissolved inorganic nutrients, phytoplankton and zooplankton. The results obtained are given in Table 19-26 (Fig. 19-23).

7.1. Tidal amplitude: (Table 19-20, Fig. 19-22).

Tides of Cochin backwater were of mixed semidiurnal type with substantial difference in range and time. The results indicated that the maximum tidal amplitude to 78 cm at 1200 hours and 76 cm at 1300 hours were observed in station II and III respectively. Likewise a minimum tidal amplitude of 16 cm at 0600 hours and 21cm of 0700 hours were observed in station II and III respectively.

7.2. Water temperature: (Table 19-20, Fig. 19-22).

Water temperature in both the stations were found to be the lowest (28°C) during early morning hours with a marginal increase noticed further. The highest temperature of 32.5°C was recorded during 1200 hours and 1300 hours at station II and III respectively.

7.3. Salinity: (Table 19-20, Fig. 19-22).

The salinity of the both stations were found to be parallel with tide. In station II, the maximum salinity of 4.28‰ was obtained during 1200 hours and lowest of 2.16‰ during 0600 hours, when the tides were in the highest and lowest amplitudes respectively. In station III also, the maximum and minimum salinity of 2.83‰ and 1.20‰ observed during 1300 hours and 0700 hours respectively, were in line with the highest and lowest tides.

7.4. Dissolved oxygen: (Table 19-20, Fig. 19-22).

High fluctuation of dissolved oxygen content was observed in the present study. Lower value of dissolved oxygen was recorded during the morning hours, which increased gradually reaching its maximum during the afternoon. The oxygen content was again found to be reduced gradually and reached the minimum level during the next morning. A parallel fluctuation of dissolved oxygen content was observed in both the stations, where higher values were obtained during hours following highest tides with the lowest values during the lowest tides. The values of dissolved oxygen ranged between 2.16 ml/l during 0600 hours to 4.28 ml/l during 1200 hours in station II and 2.62 m /l during 0400 hours to 4.02 ml/l during 1600 hours in station III.

7.5. pH: (Table 19-20, Fig. 19-22).

The variations of pH though narrow, were found to be parallel with the tide; higher values of pH during high tide and lower values during low tide. A maximum pH value of 7.45 during 1200 hours and minimum of 7.18 during 0900 hours were recorded from station II. Comparatively high range of pH value was observed in station III with a maximum of 7.52 during 1300 hours and minimum of 7.20 during 2100 hours.

7.6. Nutrients: (Table 19-20, Fig. 23).

The concentration of all nutrients such as nitrite, nitate, phosphate and silicate was found changing with tides, with high values during ebb tide and low values during high tide.

The nitrite concentration in station II with the maximum value of 2.69 μg at/l was observed during ebb tide at 0600 hours, while during high tide at 1200 hours the value was as low as 1.66 μg at/l. Following the same distribution pattern as in station II, nitrite content in station III, showed comparatively high values ranging between 1.79 μg at/l during 1300 hours and 2.93 μg at/l during 0700 hours.

Nitrate concentration was found to follow a pattern similar to that of nitrite. A maximum nitrate concentration of 7.92 μg at/l during 0600 hours and minimum of 3.33 ug at/l at 1200 hours was recorded in station II. In station III, however, while the nitrite concentration showed higher values than that of station II, the nitrate concentration showed a comparatively low value with the concentration ranging between 3.24 μg at/l during 1300 hours and 6.95 μg at/l during 0400 hours. It was also noticed that the highest concentration of nitrate was recorded during 0400 hours, when the tide was rece ding.

Phosphate concentration showed a similar pattern of distribution as that of nitrite and nitrate, with the values inversely proportional to that of the tidal amplitude. The maximum value of 24.80 μg at/l was noticed during 0600 hours when the tide was low and minimum of 17.33 μg at/l during 1200 hours during high tide, in station II. The concentration of phosphate showed a comparatively high value in station III ranging between 20.23 μg at/l during 1300 hours at high tide and 28.21 μg at/l during 0700 hours during low tide.

A comparatively high range of silicate concentration was found to follow the same fluctuation pattern as that of other three nutrients. In station II, a maximum concentration of 106.7 μg at/l was noticed during 0600 hours and minimum of 71.5 μg at/l during 1200 hours. Station III, exhibited a very wide range of silicate concentration ranging between 54.3 μg at/l during 1300 hours and 110 μg at/l during 0700 hours. The second lowest value of silicate content was noticed during 0100 hours, after tidal amplitude reached at its highest level.

7.7. **Phytoplankton** (Table 19-20, Fig. 19-22).

The phytoplankton concentration was found to be in proportion with the tide in both the stations. The lowest value of phytoplankton number was rrecorded during lowest low tide,

TABLE 19 - DIURNAL VARIATIONS IN HYDROBIOLOGICAL PARAMETERS AT STATION II.

Hours	Tidal amplitude (cm)	Water temp. (°C)	Salinity (‰)	Dissolved oxygen (ml/l)	pH	Nitrite (µg at/l)	Nitrate (µg at/l)	Phosphate (µg at/l)	Silicate (µg at/l)	Phytoplankton (cells/m^3)
0900	45	29.5	2.43	2.82	7.18	1.83	5.22	22.78	91.0	384×10^3
1200	78	32.5	4.28	3.98	7.45	1.66	3.33	17.33	71.5	457×10^3
1500	68	32.0	3.69	4.83	7.36	1.86	4.74	18.16	89.2	418×10^3
1800	49	31.0	2.67	4.19	7.30	2.07	5.42	22.51	98.3	373×10^3
2100	57	30.5	2.97	3.23	7.33	1.95	5.65	21.20	92.6	387×10^3
2400	51	29.5	3.06	2.95	7.42	1.86	4.97	18.95	85.2	369×10^3
0300	24	29.0	2.53	2.34	7.38	2.06	5.68	21.62	99.4	301×10^3
0600	16	28.0	2.16	1.73	7.22	2.69	7.92	24.80	106.7	242×10^3
0900	41	28.5	2.25	2.42	7.25	1.92	5.06	22.04	94.4	363×10^3

TABLE 20 - DIURNAL VARIATIONS IN HYDROBIOLOGICAL PARAMETERS AT STATION III.

Hours	Tidal amplitude (cm)	Water temp. (°C)	Salinity (‰)	Dissolved oxygen (ml/l)	pH	Nitrite (µg at/l)	Nitrate (µg at/l)	Phosphate (µg at/l)	Silicate (µg at/l)	Phytoplankton (cells/m^3)
1000	44	30.0	2.02	3.28	7.34	2.43	4.27	24.70	88.3	296×10^3
1300	76	32.5	2.83	3.83	7.52	1.79	3.24	20.23	54.3	345×10^3
1600	56	31.5	2.11	4.02	7.36	2.24	4.15	23.97	76.5	312×10^3
1900	50	30.5	1.76	3.75	7.27	2.41	5.08	24.23	82.3	292×10^3
2200	54	30.0	2.25	3.86	7.32	2.26	4.62	23.90	89.9	297×10^3
0100	51	28.5	2.01	3.46	7.31	2.10	4.74	22.06	69.6	286×10^3
0400	23	28.0	1.33	2.62	7.28	2.39	6.95	24.52	99.5	256×10^3
0700	21	28.0	1.20	3.67	7.20	2.93	6.23	28.21	110.6	217×10^3
1000	36	29.5	1.94	3.10	7.27	2.36	4.37	25.93	86.4	253×10^3

which increased gradually reaching the maximum value during highest high tide. Qualitative variation of phytoplankton observed, indicated that during the low tide the fresh water algae such Oscillatoria sp. and Nostoc sp. contributed to a large percentage of the population, which had lesser distribution during high tide. On the contrary, marine species of phytoplankton observed during high tide, were represented by Coscinodiscus spp. Navicula spp., Nitzschia spp., Rhizosolenia spp., Pleurosigma spp. and Gyrosigma spp.

Quantitatively, the maximum number of phytoplankton observed in station II was 457 x 10^3 cells/m^3 during 1200 hours, with the minimum of 242 x 10^3 cells/m^3 obtained during 0600 hours. Likewise in station III, the maximum of 345 x 10^3 cells/m^3 was noticed during 1300 hours and minimum of 217 x 10^3 cells/m^3 during 0700 hours.

7.8. Zooplankton: (Table 21, 22, Fig. 19-22).

The zooplankton population was found varying along with the tide, the number reaching the maximum during the incoming tide and the receding tide. However, their number was found lesser during highest high tide and during lowest low tide. It was also observed that the number of zooplankton per unit area was more during night hours than during day time.

In station II, the maximum number of zooplankton recorded was during 2100 hours, the number being $384/m^3$ and the minimum number of $91/m^3$ was observed during 0600 hours. In station III, the number ranged between $94/m^3$ during 1300 hours to $260/m^3$ during 0400 hours.

Qualitatively, from the table 19, 20 it is evident that copepods were the most dominant group contributing the largest share through the study period in both the stations. Decapod larvae was the next dominant group, followed by fish egg and larvae. As high as 294 number/m^3 copepods were recorded in station II during 2100 hours, and the number got reduced greatly reaching to a minimum of $44/m^3$ during 0600 hours. In station III, the number of copepods ranged from $71/m^3$ during 1300 hours to $126/m^3$ during 2200 hours, with the exception of $45/m^3$ during 0700 hours.

A differential distribution pattern of decapod larvae was observed in station II and III, with the maximum distribution during day time than in the night time in station II. However, in station III, the abundance was maximum during the night hours. In station II as high as 92 number/m^3 decapod larvae were noticed during 1500 hours. In station III a maximum of 57 number/m^3 was recorded during 2200 hours and 0400 hours.

The number of fish egg and larvae also showed similar pattern of distribution as in decapod larvae in station III, with maximum quantity recorded during the night hours, whereas station II contributed almost to same number throughout the period except during 0900 hours, when the maximum number recorded was $56/m^3$.

An interesting distributional pattern was observed in case of amphipods, the number being very low during the day time, but increasing gradually towards the late night hours. However, the maximum of 28 number/m^3 of amphipods was recorded during 0300 hours in station II. In station III, the highest concentration of 41 number/m^3 was observed during 0700 hours.

The distribution of cladocerans was setting an almost a similar trend in both the stations with their abundance inversely proportional to the tidal amplitude. The maximum number was observed during ebb tide and minimum during flood tide.

In station II, the miscellaneous group mainly represented by rotifers formed a maximum of 26 number/m^3 during 2100 hours while in station II this group was not well represented.

TABLE 21 - DIURNAL VARIATIONS IN ZOOPLANKTON ABUNDANCE AT STATION II

Groups of zooplankton	0900 hours	1200 hours	1500 hours	1800 hours	2100 hours	2400 hours	0300 hours	0600 hours	0900 hours
Polychaetes	-	-	-	-	3	-	-	-	-
Cladocerans	21	3	12	18	9	4	9	3	12
Copepods	140	66	88	133	294	193	84	44	114
Amphipods	8	3	3	11	4	12	28	16	11
Decapod larvae	29	37	92	59	25	23	32	11	34
Fish egg and larvae	56	16	28	26	23	21	29	17	33
Miscellaneous group	3	2	6	3	26	3	7	-	9
Total	257	127	229	250	384	256	189	91	213

TABLE 22 - DIURNAL VARIATIONS IN ZOOPLANKTON ABUNDANCE AT STATION III.

Groups of zooplankton	1000 hours	1300 hours	1600 hours	1900 hours	2200 hours	0100 hours	0400 hours	0700 hours	1000 hours
Polychaetes	-	-	-	-	-	-	1	5	1
Cladocerans	12	3	4	14	10	11	14	14	10
Copepods	111	71	121	119	126	123	103	45	96
Amphipods	7	2	14	22	18	14	8	41	27
Decapod larvae	24	12	29	25	57	48	57	29	32
Fish egg and larvae	13	3	17	12	43	31	45	19	19
Miscellaneous group	2	3	4	2	-	-	2	3	2
Mullet larvae	-	-	-	-	3	-	-	-	-
Total	169	94	189	194	257	227	260	156	187

7.9. Abundance of fry:

Variation in total abundance of fry and relative abundance of different species are given in table 23-24 (Fig. 19-20).

Four species of fry such as L. parsia, L. macrolepis, M. cephalus and M. cyprinoides were recorded during the present study. Among these, L. parsia was the most dominant species caught, followed by M. cephalus. A few number of larvae of M. cyprinoides was recorded during the high tide in both the stations.

A maximum of 66 number of fry/unit effort was obtained during 2100 hours in station II with their total absence in the catch during 0600 hours.

In station III, the abundance of fry ranged between 34 number /unit effort during 0700 hours and 144 number/unit effort during 2200 hours. However, during the highest high tide and during lowest low tide the number was found to be minimum in both the stations.

7.10. Juveniles:

Variations in total abundance of juveniles and the relative abundance of different species are given in table 25-26 (Fig. 21-22).

TABLE 23 - DIURNAL VARIATIONS ON THE ABUNDANCE OF FRY OF CULTIVABLE FISHES AT STATION II (NUMBER/UNIT EFFORT)

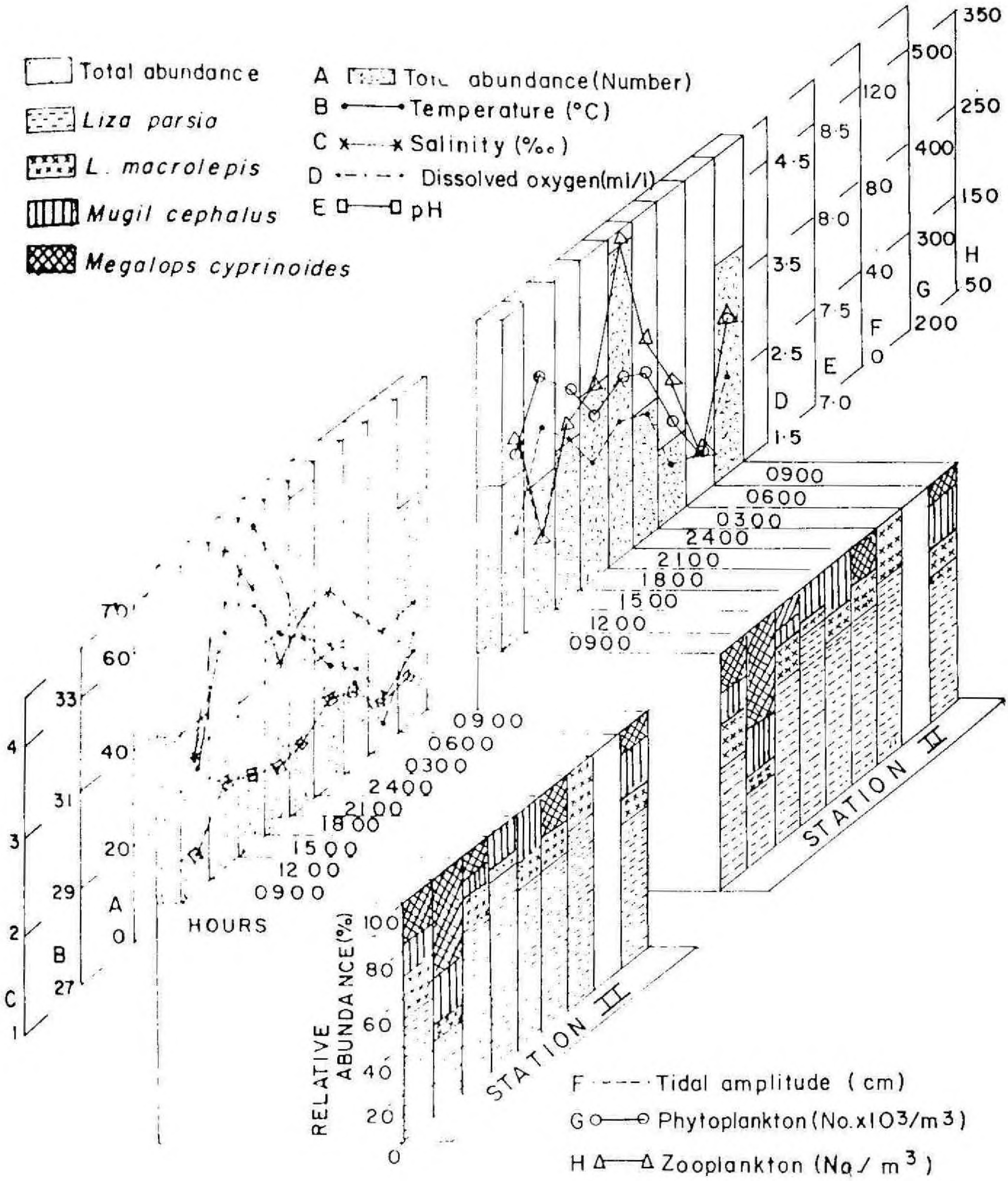
Species/time	0900 hours	1200 hours	1500 hours	1800 hours	2100 hours	2400 hours	0300 hours	0600 hours	0900 hours
Liza parsia	18	9	21	32	45	19	12	-	28
L. macrolepis	6	2	5	2	7	4	4	-	5
Mugil cephalus	5	6	2	6	14	-	-	-	10
Megalops cyprinoides	6	12	4	-	-	5	-	-	4
Total	35	29	32	40	6.	28	16	-	47

TABLE 24 - DIURNAL VARIATIONS ON THE ABUNDANCE OF FRY OF CULTIVABLE FISHES AT STATION III (NUMBER/UNIT EFFORT)

Species/time	1000 hours	1300 hours	1600 hours	1900 hours	2200 hours	0100 hours	0400 hours	0700 hours	1000 hours
Liza parsia	32	19	25	32	87	38	34	21	29
L. macrolepis	7	-	6	6	23	4	6	7	5
Mugil cephalus	6	7	7	12	32	13	9	6	10
Megalops cyprinoides	9	12	6	-	2	4	-	-	5
Total	54	38	44	50	144	59	49	34	49

Fig. 19. Diel variations on the abundance of fry in relation to hydrobiological parameters at station II.

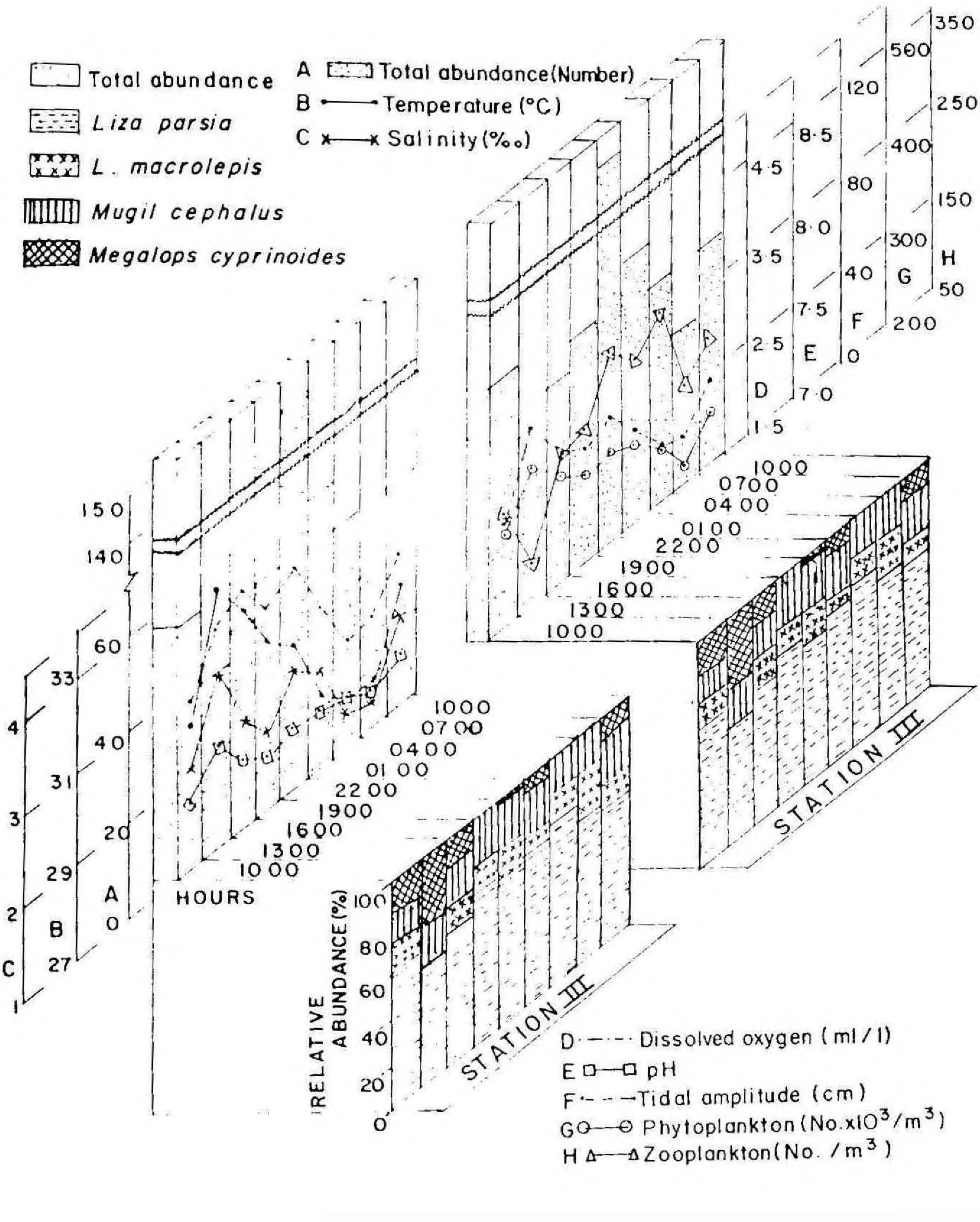
Fig. 19



Total abundance
Liza parsia
L. macrolepis
Mugil cephalus
Megalops cyprinoides
A Total abundance (Number)
B Temperature (°C)
C Salinity (‰)
D Dissolved oxygen (ml/l)
E pH
F Tidal amplitude (cm)
G Phytoplankton (No.x10³/m³)
H Zooplankton (No./m³)
HOURS
RELATIVE ABUNDANCE (%)
STATION I
STATION II
0900
1200
1500
1800
2100
2400
0300
0600
0900

Fig. 20. Diel variations on the abundance of fry in relation to hydrobiological parameters at station III.

Fig. 20



Total abundance
Liza parsia
L. macrolepis
Mugil cephalus
Megalops cyprinoides
A Total abundance(Number)
B Temperature (°C)
C Salinity (‰)
D Dissolved oxygen (ml/l)
E pH
F Tidal amplitude (cm)
G Phytoplankton (No.x10³/m³)
H Zooplankton (No./m³)
HOURS
1000
1300
1600
1900
2200
0100
0400
0700
1000
RELATIVE ABUNDANCE (%)
STATION III

TABLE 25 - DIURNAL VARIATIONS ON THE ABUNDANCE OF JUVENILES OF CULTIVABLE FISHES AT STATION II (NUMBER/UNIT EFFORT)

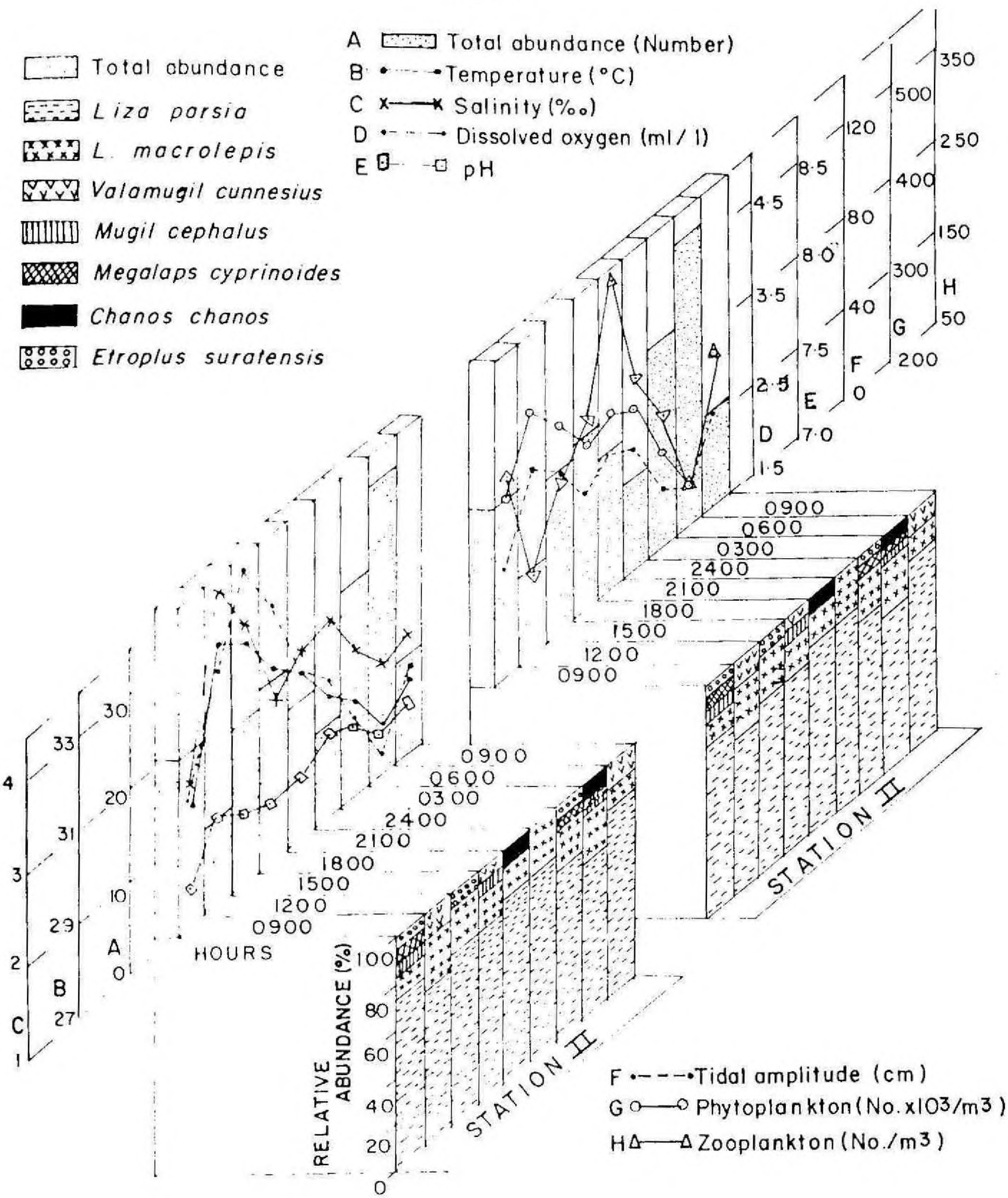
Species/time	0900 hours	1200 hours	1500 hours	1800 hours	2100 hours	2400 hours	0300 hours	0600 hours	0900 hours
Liza parsia	14	6	12	14	12	8	17	21	9
L. macrolepis	2	2	4	3	2	2	4	7	1
Valamugil cunnasius	-	1	-	1	-	-	-	-	1
Mugil cephalus	1	-	-	1	-	-	-	1	-
Megalops cyprinoides	1	-	-	-	-	-	1	1	-
Chanos chanos	-	-	-	-	1	-	-	2	-
Etroplus suratensis	1	-	1	-	-	-	1	-	-
Total	19	9	17	19	15	10	23	32	11

TABLE 26 - DIURNAL VARIATION ON THE ABUNDANCE OF JUVENILES OF CULTIVABLE FISHES AT STATION III
(NUMBER/UNIT EFFORT)

Species/time	1000 hours	1300 hours	1600 hours	1900 hours	2200 hours	0100 hours	0400 hours	0700 hours	1000 hours
Liza parsia	11	3	7	8	7	4	8	14	12
L. macrolepis	3	-	1	2	3	2	-	1	3
Valamugil cunnesius	-	-	-	-	-	1	2	-	-
Mugil cephalus	1	-	-	-	1	-	-	1	-
Megalops cyprinoides	-	-	-	1	-	-	1	-	-
Chanos chanos	-	-	-	-	1	-	1	2	1
Etroplus suratensis	1	-	-	-	1	-	-	-	1
Total	16	3	8	11	13	7	12	18	17

Fig. 21. Diel variations on the abundance of juveniles in relation to hydrobiological parameters at station II.

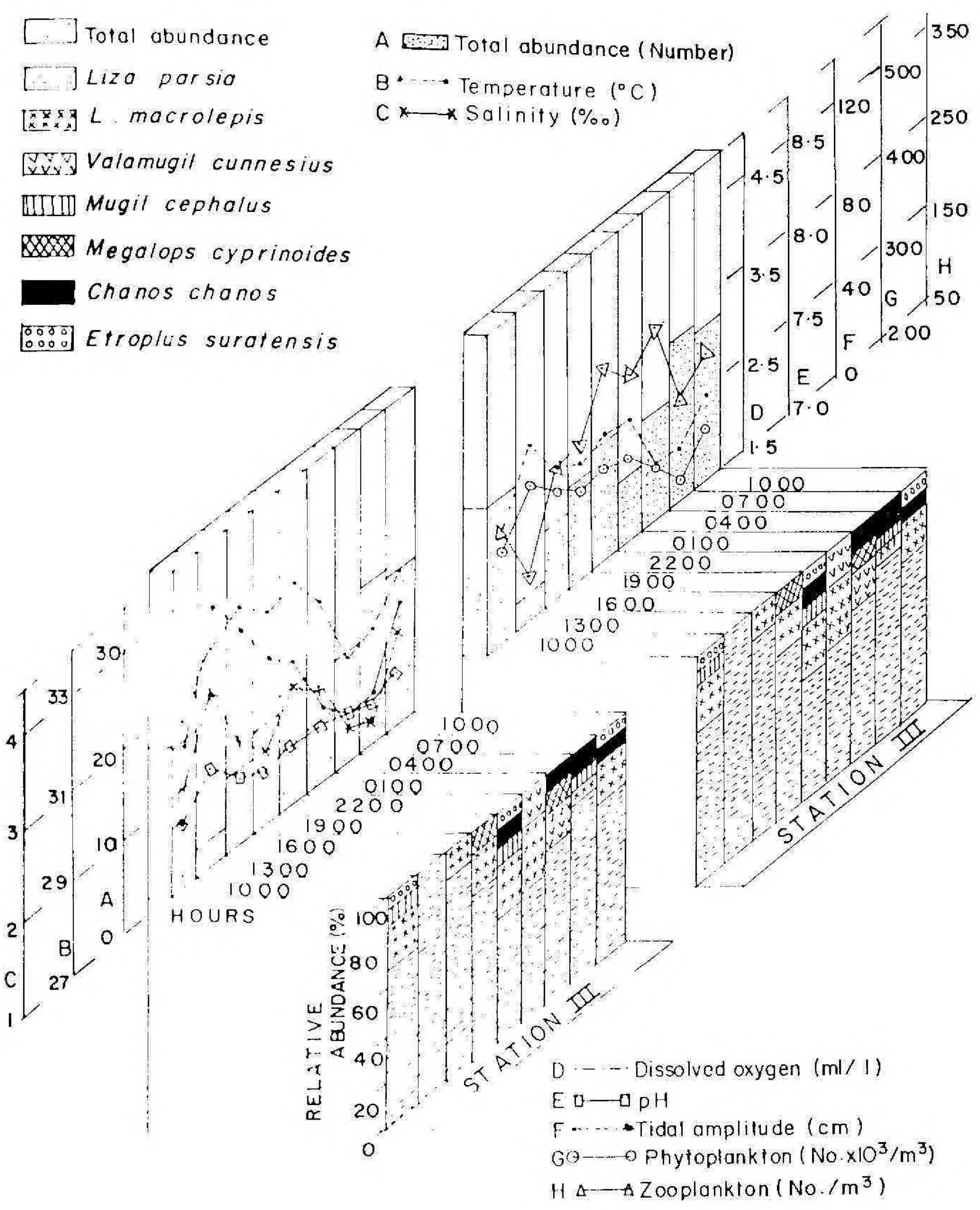
Fig. 21



Total abundance
Liza parsia
L. macrolepis
Valamugil cunnesius
Mugil cephalus
Megalaps cyprinoides
Chanos chanos
Etroplus suratensis
A Total abundance (Number)
B Temperature (°C)
C Salinity (‰)
D Dissolved oxygen (ml/l)
E pH
F Tidal amplitude (cm)
G Phytoplankton (No.x10³/m³)
H Zooplankton (No./m³)
HOURS
RELATIVE ABUNDANCE (%)
STATION II
STATION II

Fig. 22. Diel variations on the abundance of juveniles in relation to hydrobiological parameters at station III.

Fig. 22

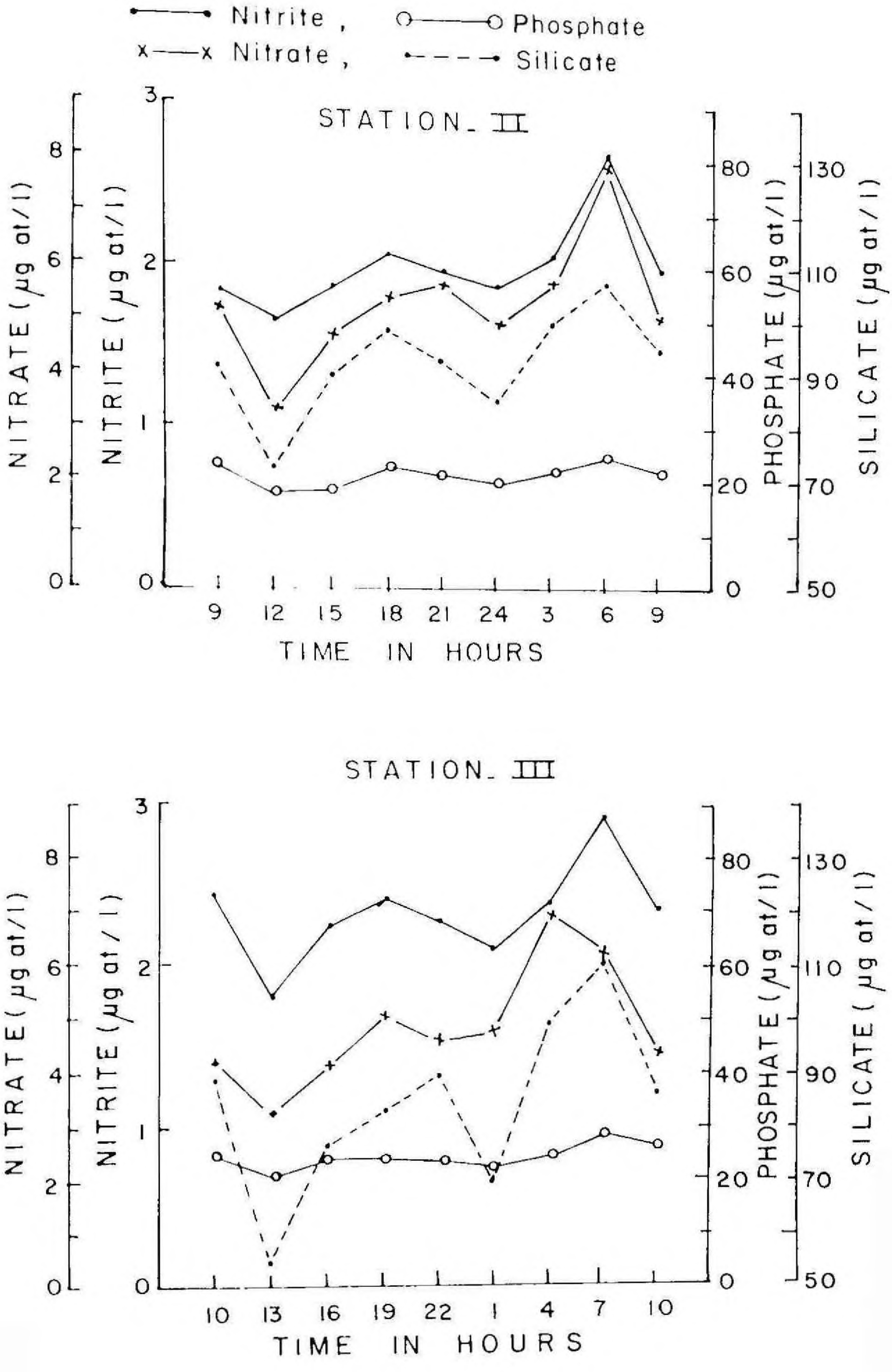


Total abundance
Liza parsia
L. macrolepis
Valamugil cunnesius
Mugil cephalus
Megalops cyprinoides
Chanos chanos
Etroplus suratensis
A Total abundance (Number)
B Temperature (°C)
C Salinity (‰)
D Dissolved oxygen (ml/l)
E pH
F Tidal amplitude (cm)
G Phytoplankton (No.x10³/m³)
H Zooplankton (No./m³)
HOURS
1000
1300
1600
1900
2200
0100
0400
0700
1000
RELATIVE ABUNDANCE (%)
STATION III
STATION II

Fig. 23 . Diel variations in nutrients concentration at station II.

Fig. 23 . Diel variations in nutrients concentration at station III.

Fig. 23


Nitrite, Phosphate
Nitrate, Silicate
STATION_ II
NITRATE (μg at/l)
NITRITE (μg at/l)
PHOSPHATE (μg at/l)
SILICATE (μg at/l)
9 12 15 18 21 24 3 6 9
TIME IN HOURS
STATION_ III
NITRATE (μg at/l)
NITRITE (μg at/l)
PHOSPHATE (μg at/l)
SILICATE (μg at/l)
10 13 16 19 22 1 4 7 10
TIME IN HOURS

In station II, a maximum of 32 number of juveniles per unit effort was obtained during 0600 hours with a minimum of 9 number/unit effort during 1300 hours.

A similar trend of dominance of juveniles were recorded in station III, like that of station II, with a maximum number of 18/unit effort during 0700 hours and minimum of 3/unit effort during 1300 hours. However it was observed that, station II was rich in abundance of juveniles than station III.

Among the species recorded, L. parsia was dominating in abundance followed by L. macrolepis. However, sporadic catches of V. cunnesius, M. cephalus, M. cyprinoides, C. chanos and E. suratensis were also obtained.

The abundance of juveniles were maximum during the lowest low tide both in number and species.

7.11. Tidal amplitude in relation to seed abundance:

The present study revealed that the fry of L. parsia, L. macrolepis and M. cephalus were abundant during the incoming high tide followed by the receding tide (Table 17, 18, 21, 22). Nevertheless, the distribution was found to be minimum during the highest high tide and lowest low tide. But larvae of M. cyprinoides were observed during incoming high tide and at the highest high tide.

The number of juveniles caught was found to be inversely proportional with the tidal amplitude. The maximum abundance of juveniles was observed during 0600 hours in station II and 0700 hours in station III when the tidal amplitude was at its lowest level. The minimum number of juveniles was recorded during 1200 hours in station II and 1300 hours in station III, when the highest tidal amplitude was recorded.

7.12. Time of collection in relation to seed abundance:

It was observed that the fry were abundant during morning and evening hours, compared to the afternoon and late night hours. However, in the case of juveniles, no such difference in their abundance was noticed between day and night.

7.13. Temperature in relation to seed abundance:

Further, the fry and juveniles were found to be abundant during morning and evening hours, when the temperature was comparatively low.

8. STATISTICAL ANALYSIS:

The data of different characteristics was processed for mean and standard deviation and the results obtained are given in table-27. Similarly, to understand the interrelationships, the correlation analysis were carried out and the significant relations observed among the hydrobiological features and between these parameters with the abundance of fry and juveniles are given in table 28-31. The data obtained in diurnal variation studies were also processed similarly for both station II and III together and significant relationship noticed are shown in table 32-33.

TABLE 27. MEAN AND STANDARD DEVIATION OF DIFFERENT CHARACTERISTICS AT STATION I - IV

Character	Station I	Station II	Station III	Station IV
Temperature	30.600 ± 1.391	30.333 ± 1.332	30.091 ± 1.429	30.000 ± 1.537
Salinity	6.579 ± 5.182	11.365 ± 8.354	6.403 ± 4.463	21.733 ± 11.159
Dissolved oxygen	4.066 ± 0.635	3.015 ± 0.718	3.178 ± 0.502	3.655 ± 2.119
pH	7.185 ± 0.789	7.704 ± 0.223	7.772 ± 0.272	6.102 ± 3.028
Nitrite	1.071 ± 0.275	1.372 ± 0.531	1.736 ± 0.699	0.885 ± 0.538
Nitrate	4.570 ± 2.266	4.065 ± 1.871	4.263 ± 1.330	2.493 ± 2.226
Phosphate	4.711 ± 3.098	16.474 ± 11.094	20.315 ± 6.973	110.955 ± 227.372
Silicate	28.260 ± 25.927	32.593 ± 26.892	44.532 ± 26.216	90.787 ± 182.049
Phytoplankton	212.400 ± 146.218	482.533 ± 193.685	446.455 ± 184.436	350.733 ± 311.594
Zooplankton	114.133 ± 51.134	332.267 ± 143.885	157.182 ± 40.828	544.000 ± 415.964
Fry	12.000 ± 19.416	67.200 ± 34.623	64.091 ± 51.878	29.300 ± 17.209
Juveniles	6.933 ± 6.273	17.667 ± 5.341	14.364 ± 5.025	8.179 ± 11.126

TABLE 28. CORRELATION MATRIX FOR DIFFERENT CHARACTERISTICS AT STATION I

Character	Temp.	Salin.	Do_2	pH	No_2	No_3	Po_4	Sio_4	Phyto.	Zoopl.	Fry	Juve.
Temperature	1.000	0.651**	-0.162	0.158	-0.616*	-0.189	0.504	-0.611*	0.717**	0.573*	0.171	0.079
Salinity	0.651**	1.000	0.191	-0.223	0.633*	-0.556*	0.260	-0.568*	0.428	0.553*	0.717**	0.331
Dissolved oxygen	-0.162	0.191	1.000	-0.360	-0.011	-0.016	-0.300	0.150	-0.2 5	-0.168	0.494	0.064
pH	0.158	-0.223	-0.360	1.000	0.269	0.225	0.190	-0.073	0.131	0.032	-0.602*	-0.440
Nitrite	-0.616*	-0.633*	-0.011	0.269	1.000	0.434	0.136	0.498	-0.261	-0.373	-0.595*	-0.366
Nitrate	-0.189	-0.556*	-0.016	0.225	0.480	1.000	0.290	0.278	-0.219	-0.041	-0.628*	-0.484
Phosphate	0.504	0.260	-0.300	0.190	0.136	0.290	1.000	-0.175	0.233	0.379	-0.261	-0.408
Silicate	-0.611*	-0.568*	0.150	-0.073	0.498	0.278	-0.175	1.000	-0.562*	-0.653**	-0.344	-0.460
Phytoplankton	0.717**	0.428	-0.265	0.131	-0.261	-0.219	0.233	-0.562*	1.000	0.460	0.048	0.318
Zooplankton	0.573*	0.553*	-0.168	0.032	-0.373	-0.041	0.379	-0.653**	0.460	1.000	0.189	0.409
Fry	0.171	0.717**	0.494	-0.602*	-0.595*	-0.628*	-0.261	-0.344	0.048	0.189	1.000	0.538*
Juveniles	0.079	0.331	0.064	-0.440	-0.366	-0.481	-0.408	-0.406	0.318	0.409	0.583*	1.000

* Significant at 5% level ** Significant at 1% level.

TABLE 29. CORRELATION MATRIX FOR DIFFERENT CHARACTERISTICS AT STATION II

Character	Temp.	Salin.	Do_2	pH	No_2	No_3	Po_4	Sio_4	Phyto.	Zoopl.	Fry	Juve.
Temperature	1.000	0.724**	0.317	0.568*	-0.634*	-0.482	-0.494	-0.731**	0.327	0.613*	0.311	0.554*
Salinity	0.724**	1.000	0.568*	0.156	-0.852**	-0.652**	-0.628*	-0.551*	-0.055	0.798**	0.672**	0.624*
Dissolved oxygen	0.317	0.568*	1.000	-0.074	-0.336	0.049	0.000	-0.191	-0.504	0.530*	0.372	0.069
pH	0.568*	0.156	-0.074	1.000	-0.374	-0.314	-0.268	-0.648**	0.606*	0.224	-0.129	0.140
Nitrite	-0.634*	-0.852**	-0.336	-0.374	1.000	0.662**	0.566*	0.569*	-0.199	-0.685**	-0.504	-0.457
Nitrate	-0.482	-0.652**	0.049	-0.314	0.662**	1.000	0.875**	0.479	-0.411	-0.361	-0.470	-0.637*
Phosphate	-0.494	-0.628*	0.000	-0.268	0.566*	0.875**	1.000	0.662**	-0.478	-0.408	-0.269	-0.661**
Silicate	-0.731**	-0.551*	-0.194	-0.648**	0.569*	0.479	0.662**	1.000	-0.524*	-0.476	0.024	-0.521*
Phytoplankton	0.327	-0.055	-0.504	0.606*	-0.199	-0.411	-0.478	-0.524*	1.000	-0.251	-0.346	0.199
Zooplankton	0.613*	0.798**	0.530*	0.224	-0.685**	-0.361	-0.408	-0.476	-0.251	1.000	0.460	0.299
Fry	0.311	0.672**	0.372	-0.129	-0.504	-0.470	-0.269	0.024	-0.346	0.460	1.000	0.576*
Juveniles	0.554*	0.624*	0.069	0.140	-0.457	-0.637*	-0.661**	-0.521*	0.199	0.299	0.576*	1.000

*Significant at 5% level ** Significant at 1% level.

TABLE 30. CORRELATION MATRIX FOR DIFFERENT CHARACTERISTICS AT STATION III

Character	Temp.	Salin.	Do_2	pH	No_2	No_3	Po_4	Sio_4	Phyto.	Zoopl.	Fry	Juve.
Temperature	1.000	0.703*	-0.223	0.503	-0.824**	-0.264	-0.491	-0.611*	0.687*	0.625*	-0.034	0.698*
Salinity	0.703*	1.000	-9.212	0.194	-0.535	0.080	-0.164	-0.311	0.278	0.632*	9.368	0.332
Dissolved oxygen	-0.223	-0.212	1.000	0.145	0.422	0.301	0.496	0.471	-0.299	-0.118	0.657*	-0.424
pH	0.503	0.194	0.145	1.000	-0.590	-0.487	-0.564	-0.754	0.748	-0.061	-0.061	0.111
Nitrite	-0.824**	-0.535	0.422	-0.590	1.000	0.601	0.801**	0.830**	-0.852**	-0.340	0.360	-0.658*
Nitrate	-0.264	0.080	0.301	-0.487	0.601	1.000	0.846**	0.567	-0.632*	0.078	0.282	-0.485
Phosphate	-0.491	-0.164	0.496	-0.564	0.801**	0.946**	1.000	0.807**	-0.807**	-0.157	0.390	-0.556
Silicate	-0.611*	-0.311	0.471	-0.754**	0.830**	0.567	0.808**	1.000	-0.817**	-0.067	0.517	-0.399
Phytoplankton	0.687*	0.278	-0.299	0.748**	-0.852**	-0.632*	-0.807**	-0.817**	1.000	0.210	-0.347	0.422
Zooplankton	0.625*	0.632*	-0.118	-0.061	-0.340	0.078	-0.157	-0.067	0.210	1.000	0.305	0.321
Fry	-0.034	0.368	0.657*	-0.061	0.304	0.282	0.390	0.517	-0.347	0.305	1.000	-0.225
Juveniles	0.698*	0.332	-0.424	0.111	-0.658*	-0.485	-0.556	-0.399	0.422	0.321	-0.225	1.000

*Significant at 5% level   ** Significant at 1% level.

TABLE 31. CORRELATION MATRIX FOR DIFFERENT CHARACTERISTICS AT STATION IV

Character	Temp.	Salin.	Do_2	pH	No_2	No_3	Po_4	Sio_4	Phyto.	Zoopl.	Fry	Juve.
Temperature	1.000	0.925**	0.954**	0.992**	-0.452	-0.495	-0.760**	-0.770**	0.695**	0.841**	0.072	-0.963**
Salinity	0.925**	1.000	0.922**	0.917**	-0.360	-0.429	-0.628*	-0.640*	0.617*	0.796**	0.348	-0.825**
Dissolved oxygen	0.954**	0.922**	1.000	0.958**	-0.515*	-0.535*	-0.745**	-0.750**	0.667**	0.719**	0.165	-0.914**
pH	0.992**	0.917**	0.958**	1.000	-0.421	-0.485	-0.716**	-0.730**	0.686**	0.811**	0.044	-0.950**
Nitrite	-0.452	-0.364	-0.515*	-0.421	1.000	0.938**	0.805**	0.818**	-0.367	-0.374	-0.127	9.573*
Nitrate	-0.495	-0.429	-0.535*	-0.485	0.938**	1.000	0.684**	0.826**	-0.408	-0.438	-0.194	0.584*
Phosphate	-0.760**	-0.628*	-0.745**	-0.716**	0.805**	0.684**	1.000	0.990**	-0.562*	-0.660**	-0.007	0.855**
Silicate	-0.770**	-0.640*	-0.750**	-0.730**	0.818**	0.726**	0.990**	1.000*	-0.566*	-0.673**	-0.010	0.873**
Phytoplankton	0.695**	0.617*	0.667**	0.686**	-0.367	-0.408	-0.562	-0.566*	1.000	0.565*	0.209	-0.730**
Zooplankton	0.841**	0.796**	0.719**	0.811**	-0.374	-0.438	-0.660**	-0.673**	0.565*	1.000	0.212	-0.828**
Fry	0.072	0.348	0.165	0.044	-0.127	-0.194	-0.008	-0.010	0.209	0.212	1.000	0.007
Juveniles	-0.963**	-0.825**	-0.914**	-0.950**	0.573*	0.584*	0.855**	0.873**	-0.730**	-0.828**	0.007	1.000

*Significant at 5% level ** Significant at 1% level.

TABLE 32. STANDARD DEVIATION FOR DIURNAL VARIATIONS OF DIFFERENT CHARACTERISTICS AT STATION II AND III

Character	Station II and III
Tidal amplitude	46.667 ± 17.869
Temperature	29.944 ± 1.504
Salinity	2.416 ± 0.764
Dissolved oxygen	3.282 ± 0.780
pH	7.321 ± 0.086
Nitrite	2.045 ± 0.391
Nitrate	5.091 ± 1.154
Phosphate	22.619 ± 2.783
Silicate	88.094 ± 13.776
Phytoplankton	324.889 ± 65.511
Zooplankton	207.278 ± 6.9.513
Fry	45.222 ± 29.160
Juveniles	14.444 6.688

TABLE 33. CORRELATION MATRIX FOR DIRUNAL VARIATIONS OF DIFFERENT CHARACTERISTICS AT STATION II AND III

Character	T.amp.	Temp.	Salin.	Do_2	pH	No_2	No_3	Po_4	Sio_4	Phyto.	Zoopl.	Fry	Juve.
Tidal amplitude	1.00	0.889**	0.724**	0.812**	0.680**	-0.197	-0.822**	-0.718**	-0.794**	0.757**	0.059	0.238	-0.667**
Temperature	0.889**	1.000	0.704**	0.829**	0.687**	-0.114	-0.741**	-0.599**	-0.650**	0.680**	-0.09.	0.059	-0.436
Salinity	0.724**	0.784**	1.000	0.470*	0.616**	-0.206	-0.471*	-0.913**	-0.387	0.892**	0.028	-0.168	-0.137
Dissolved oxygen	0.812**	0.829**	0.470*	1.000	0.169*	-0.110	-0.672**	-0.423	-0.543*	0.508*	0.122	0.335	-0.502*
pH	0.680**	0.687**	0.616**	0.469*	1.000	-0.130	-0.646**	-0.678**	-0.692**	0.448	-0.200	-0.021	-0.555*
Nitrite	-0.197	-0.114	-0.206	-0.110	-0.130	1.000	0.198	0.166	-0.008	-0.269	0.006	0.133	0.218
Nitrate	-0.822**	-0.741**	-0.471*	-0.772**	-0.646**	0.198	1.000	0.451	0.820**	-0.495	0.139	-0.269	0.712**
Phosphate	-0.718**	-0.599**	-0.913**	-0.423	-0.678**	0.166	0.451	1.000	0.495*	-0.872**	-0.119	0.163	0.339
Silicate	-0.794**	-0.650**	-0.387	-0.543*	-0.692**	-0.008	0.820**	0.495*	1.000	-0.366	0.219	-0.133	0.788**
Phytoplankton	0.757**	0.680**	0.892**	0.508*	0.448	-0.269	-0.495*	-0.872**	-0.366	1.000	0.264	-0.072	-0.281
Zooplankton	0.059	-0.097	0.028	0.122	-0.200	0.006	0.139	-0.119	0.219	0.264	1.000	0.443	-0.077
Fry	0.238	0.059	-0.168	0.335	-0.021	0.133	-0.269	0.163	-0.133	-0.072	0.443	1.000	-0.354
Juveniles	-0.667**	-0.436	-0.137	-0.502*	-0.555*	0.218	0.712**	0.339	0.788**	-0.281	-0.077	-0.0354	1.000

*Significant at 5% level   ** Significant at 1% level.

DISCUSSION

Cochin backwater, by virtue of its permanent connection with the Arabian sea and by the large numbers of rivers draining into it,has a rich supply of planktonic food, which makes it an ideal nursery ground for the fry and juveniles of many finfishes and crustaceans. The environment is mostly influenced by monsoon, which results in pronounced seasonal variation in the environmental parameters as well as in the primary and secondary productions. The high river influx and copious land drainage during monsoon, add large amount of nutrients to the system, which ultimately cause the flowering of primary producers. The secondary producers, thriving on this primary producers, form an important component of the food chain, and these together form the basic food item for the fry and juveniles of most of the cultivable fishes. The dynamic interaction among the various parameters in the backwater system, influencing the recruitment of fish seed resources are discussed here.

Three seasons are recognised in a year on the basis of climatic condition and monsoonal effect along the south west coast of India. These are the premonsoon season (February-May), monsoon season (June-September) and the postmonsoon season (October-January). Although the period for the present investigation was restricted only from February to September, two seasons were well demarcated on the basis of rainfall data recorded. The total rainfall recorded in the investigation period was 227 cm, with the maximum amount during June indicating the onset of monsoon. The rainfall data recorded was found to be much less than the average rainfall of 323 cm.

The temperature regime of Cochin backwater system generally within a narrow range has been found to be influenced by various factors like rainfall and freshwater efflux (Gopinathan, 1972; Kumaran and Rao, 1975), Solar radiation (Sankaranarayanan and Qasim 1969; Silas and Pillai, 1975) and flow of underwater currents. Though the causative factors are many, a general distributional pattern of high during premonsoon and postmonsoon season, with a lowering during south west monsoon season has been established in Cochin backwater (Gopinathan, 1972; Kumaran and Rao, 1975; Pillai et al., 1975; Silas and Pillai, 1975). In the present investigation the temperature pattern during different seasons has been in agreement with the earlier observation, where the values were as high as 32.5°C during premonsoon followed by an abrupt decrease during the monsoon with a minimum value of 28°C. Unlike the profound seasonal fluctuation, temperature in general was found to show very little variation among the four stations studied. Nevertheless, it can be concluded that while the fluctuation in station I, II and III can be mainly due to freshwater influx, because of their comparative nearness to the head stream, that obtained in station IV may be mainly due to under water current caused by the adjacent marine environment.

Among the various environmental parameters, salinity is found to have tremendous influence on the existance of flora and fauna in an estuarine system. The variations of salinity are very wide because of the differential influence of tide and heavy fresh water drainage during monsoon. Earlier observations have shown that the surface salinity remains high during the premonsoon which is reduced greatly with the onset of monsoon (Manikoth and Salih, 1974; Kumaran and Rao, 1975; Pillai et al.,1975). In the present study also during premonsoon season, salinity of all the stations was very high which may be due to the heavy influence of tide and lesser influence of freshwater run off. But with the onset of monsoon, the values were found to decrease drastically and this can be attributed to the influence of heavy freshwater run off and land drainage. Wide fluctuations of salinity observed among the stations; indicated the influence of their proximity to freshwater or marine environment. Salinity was found showing a decreasing trend with the increase in distance from stations at bar mouth to those at upstream. The extent of intrusion of saline water depends on the strength of tidal influx and freshwater efflux which differ with seasons. Among the four stations studied here, station IV showed comparatively high salinity throughout the period, thereby confirming the influence of seawater and less mixing with freshwater. Similarly, in station I, comparatively low salinity range was observed and the water was almost fresh during the month of August which may be owing to the heavy freshwater run off and the least tidal influence. Likewise in station II and III also, the salinity with a higher concentration than that of station I, reached at its minimum level during monsoon.

Dissolved oxygen in water which is vital for all living beings, plays a very important role in aquatic life. Variations in dissolved oxygen concentration in Cochin backwater in terms of time and space were studied by several workers(Haridas et al., 1973; Kumaran and Rao, 1975; Pillai et al., 1975; Silas and Pillai, 1975). According to them, the dissolved oxygen content was high during the monsoon than during premonsoon season, probably due to heavy precipitation. Nevertheless, observations made by Nair et al.(1983) and Nair and Abdul Azis (1987) in Ashtamudi estuary indicated that the very low concentration of dissolved oxygen towards the close of premonsoon season and early monsoon, is believed to be caused due to intense pollution and eutrophication. In the present study, highest concentration of dissolved oxygen is observed during monsoon season in station I and III, which may be due to heavy precipitation; while in station II and IV, the lowest value of dissolved oxygen concentration observed during monsoon may be attributed to eutrophication caused by mud bank formation in the sea (station IV) and the influence of these water being carried by tidal influence to station II, which is situated in proximity to marine environment (Fig. 1). Station IV showed a comparatively high concentration of dissolved oxygen throughout the study period which can be attributed to characteristic breaking of waves and dilution of atmospheric oxygen.

The pH of surface water showed considerable fluctuations in time and space. Earlier observations in Cochin backwater (Sankaranarayanan and Qasim, 1969; Silas and Pillai, 1975) and in Ashtamudi estuary (Nair et al., 1983) showed that the maximum pH in these waters observed during premonsoon season was mainly due to the influence of seawater of high pH with the minimum range during the monsoon period. During the present investigation also, it could be seen that higher pH prevailed during premonsoon season in all the stations, with low values obtained during monsoon season.

Nair *et al.* (1983) showed that high pH of the marine zone was on account of the intrusion of high saline seawater and that low values of river zone could be due to the influence of freshwater and effluent discharges. Among the four stations studied under the present investigation, station IV representing the marine zone was found to have the highest pH values. The ranges were found to decrease in other stations with the increase in distance from the marine environment to the upstream, thereby confirming the earlier observations. Nevertheless, the range of pH in representative station was found to be little in station I and IV, compared to the other stations. In station IV, this may be due to the extensive buffering capacity of the sea water which allows only little pH changes (Martin, 1970). In station I, the low range in pH value may be due to the least influence of tidal water.

Nutrients in general, showed marked rhythm in their distribution in time and space. Higher concentration of nutrients was recorded in all stations during monsoon months than during premonsoon periods. The value of NO_2-N was found to be very low during premonsoon period in all the stations and this increased after the onset of monsoon, which may be due to influence of freshwater run off and land drainage. Sankaranarayanan and Qasim (1969), and Manikoth and Salih (1974) observing similar fluctuation pattern of NO_2-N in Cochin backwater, opined that it may be formed as a result of decomposition of organic nitrogen. Pillai et al. (1975) observed the differential distribution of nitrite among stations especially in their peak season of occurrence. However, in the present observation while the peak period of occurrence was during June-August invariably in all the stations, station IV representing marine environment showed comparatively low values. The reasons for this may be attributed to lesser supply of nitrate from the sea, from which NO_2-N is derived as a transitory stage during nitrogen cycle (Sankaranarayanan and Qasim, 1969).

The distribution of NO_3-N in the Cochin backwater studied by Sankaranarayanan and Qasim (1969) and Manikoth and Salih (1974), indicated the presence of very low concentration of NO_3-N throughout the year except during monsoon. A similar observation was also made in Ashtamudi estuary by Nair et al. (1983) and Nair and Abdul Azis (1987). During the present investigation also, the concentration of NO_3-N was very low in all the stations throughout the study period except for monsoon months. Available data indicate that the rainfall and land drainage are the major factors contributing to the increased nitrate concentration during monsoon months. Minimum values of NO_3-N observed in station IV throughout the period and in other stations during premonsoon can be attributed to the very little contribution of nitrate from the sea.

The phosphate concentration as studied by Sankaranarayanan and Qasim (1969), Pillai et al.(1975) is found to have two peaks, during early monsoon and during postmonsoon; while according to Manikoth and Salih 91974) the higher concentration of PO_4-P was during postmonsoon period in Cochin backwater. Similarly, Nair et al.(1983) and Nair and Abdul Azis (1987) found the increase in the phosphate value at the onset of monsoon rains, recording a peak during postmonsoon in Ashtamudi estuary. In the present study also, the distribution of PO_4-P showed similar fluctuation pattern, but with very wider variations among stations; while value as high as 35.27 μg at/l recorded in station II, the maximum value recorded in station IV was only 6.70 μg at/l . This high concentration of phosphate recorded at station II, substantiates the earlier views that phosphorus contribution of the estuary is largely influenced by external sources such as land drainage and freshwater run off (Sankaranarayanan and Qasim, 1969). Further, sediments in estuaries as reported by Mortimer (1941), Armstrong and Harvey (1950) and Rittenberg et al. (1955) and as quoted by Nair et al. (1983) are found to trap 80-90% of phosphorus releasing the same to the overlying water. According to these authors, the total phosphorus of an estuary can be taken as an index of potential fertility of an ecosystem as a whole.

Marked variation in silicate concentration was observed during the study period among the four stations. Maximum concentration of SiO_4-Si was recorded during second fortnight of July and first fortnight of August in station I, II and III, while in station IV, a very low range of silicate is discernible with an insignificant peak during August. The silicate concentration in general was found to be very low during premonsoon period which increased tremendously after the onset of monsoon. Observations by earlier workers indicate that the higher values obtained during monsoon can be effected by freshwater discharge (Sankaranarayanan and Qasim, 1969; Nair et al., 1983; Nair and Abdul Azis, 1987). This view of further substantiated by the fact in the present observation that the silicate concentration exhibits an inverse relationship with the salinity profile as has also been noticed by Sankaranarayanan and Qasim (1969).

The distribution and abundance of phytoplankton in Cochin backwaters and in other estuaries are extensively studied by several workers. The results obtained by Gopinathan (1972) and Santhanam et al. (1975) in Cochin backwater and by Mohamed and Rahaman (1987) in Agniar estuary showed that the abundance of phytoplankton is maximum during early monsoon and monsoon periods than during the premonsoon period. However, the observations by Joseph and Pillai (1975), Kumaran and Rao (1975) Gopinathan (1981) in Cochin backwater and Ramdhas (1977) in Vellar estuary indicated that the abundance of phytoplankton reached its maximum concentration during premonsoon, while minimum concentration was recorded during monsoon season. In the present study, the maximum phytoplankton concentration was recorded during premonsoon and minimum during monsoon period in all the stations except in station IV (Fig. 6-7). This is in agreement with the observations made by the later school of workers. However, the concentration of phytoplankton was found to be increasing again towards the postmonsoon periods forming a secondary peak as has also been noticed by Gopinathan (1972). Station IV (intertidal region) showed maximum abundance of phytoplankton during early monsoon months and the reason for the same may be attributed to the reduction of salinity and temperature during the early monsoon (Joseph and Pillai, 1975), coupled with comparatively higher nutrient concentration during this period. Gopinathan (1981) also obtained similar results in the inshore waters of the sea at Cochin.

The marine forms of phytoplankton such as Coscinodiscus spp. Skeletonema spp., Nitzschia spp., Pleurosigma spp, Navicula spp. and Rhizosolenia spp. were dominant through out the study period in all the stations except in station II and III during monsoon (Fig. 8). In station IV, Skeletonema costatum was found to be dominating during the premonsoon season indicating its high salinity preference. Kumaran and Rao (1975) observed the dominance of S. costatum through out the year with peak during June and September. They have also reported that there was a break in monsoon during June. The predominance of Coscinodiscus spp. throughout the study period in all the different environments brings out the tolerance of the species to higher salinity range (Joseph and Pillai, 1975). During monsoon season, the freshwater forms such as Oscillatoria sp. Nostoc sp. and Anabaena sp. contributed to a larger percentage of the total phytoplankton, especially in station II and III. This can be due to reduction of salinity by heavy efflux of freshwater to a considerable extent. Salinity changes are found to affect the distribution of dinoflagellates also (Joseph and Pillai, 1975). The species of Peridinium and ceratium found in the present study in large numbers during premonsoon, were recorded in fewer numbers during monsoon in station IV. They were completely absent during monsoon in other stations with stray occurrence during premonsoon. This indicates the preference of high salinity and temperature by the dinoflagellates and these factors are believed to play critical role in their distribution. The presence of dinoflagellates in station IV may be due to their comparatively high degree of tolerance to very low concentration of nutrients, when compared to that of the diatoms (Joseph and Pillai, 1975).

The seasonal and spatial fluctuations in the zooplankton distribution in the present investigation were reflective of hydrographical characters of the ecosystem. During the premonsoon period, the rainfall was negligible and the salinity of all stations was significantly high. Temperature also remained high during this period and the condition maintained until the onset of monsoon. The number of zooplankton per unit volume was significantly high during this period when the above condition prevailed. But the number of zooplankton was greatly reduced during the monsoon period when salinity of water decreased to a considerable level, with a corresponding decline in temperature. A similar fluctuation of zooplankton abundance during a year, with a maximum during premonsoon and a minimum during monsoon period was observed by several other workers (Menon et al., 1971; Nair and Tranter, 1971; Kumaran and Rao, 1975; Pillai et al. 1975; Silas and Pillai, 1975) in Cochin backwaters.

A parallel correlation was also observed in the present study between the abundance of zooplankton and the salinity. Station I recorded minimum abundance of zooplankton, throughout the study period due to the prevailing low salinity condition coupled with the lesser concentration of phytoplankton in this environment. This station recorded the least number of zooplankton of 37 number/m^3 during August with the lowest salinity value of 0.54‰ and a low phytoplankton concentration of 142×10^3 cells/m^3). However, station IV showed richer population of zooplankton throughout the period of study which can be correlated to the prevailing high saline condition and rich concentration of phytoplankton.

A review of the trend of the distribution of different groups of zooplankton revealed that majority of them show maximum occurrence during the high saline period (Table 6-9). Observations made by Pillai et al. (1975) and Silas and Pillai (1975) indicate the presence of brachiuran zoea only during December to May in Cochin backwater. On the otherhand, Menon et al. (1971), and Nair and Tranter (1971) reported the presence of brachiuran zoea throughout the year with maximum abundance during premonsoon. According to Pillai et al. (1975), the hydromedusae and lucifer are present only during the premonsoon, while Nair and Tranter (1971) observed the distribution of hydromedusae and lucifer throughout the year with a dominance during premonsoon. In the present investigation, hydromedusae, brachiuran zoea and lucifer were found only during premonsoon period, but were absent during monsoon season. The most important groups such as copepods and decapod larvae were also found in their maximum abundance during premonsoon period and this is in agreement with observations made by Menon et al. (1971), Pillai et al. (1975) and Rao et al. 1975. The observations made by Pillai et al. (1975) and Silas and

Pillai (1975) on the distribution and abundance of cladocerans, indicate that this group is found during the later part of the monsoon and postmonsoon months. But in present study, the cladocerans were recorded mainly during the monsoon period in station I, II and III, when the salinity of water was comparatively low and this is in line with the result obtained by the Rao et al(1975). While considering the distribution of polychaete and its larvae, it was observed that this group was dominant in station IV, compared to the other stations. According to Menon et al. (1971), Nair and Tranter (1971) and Rao et al. (1975) also, these groups were found more towards the mouth of the estuary with their seasonal abundance during premonsoon period. However, during the present investigation, this group was present both during premonsoon and monsoon season with a dominance during monsoon and this may be due to their high tolerance capacity to the turbid environment caused due to mud bank formation. George (1958), Nair and Tranter (1971), Menon et al. (1971) and Silas and Pillai (1975) recorded the maximum abundance of fish egg and larvae during postmonsoon period, whereas Rao et al. (1975)recorded them in high numbers throughout the investigation period. However, in the present study, though this group was represented throughout the investigation period in all the stations, maximum abundance was recorded towards the end of monsoon months.

An overall review of the various hydrobiological parameters enunciates certain interesting interrelationships. Earlier studies have indicated that the pronounced monsoon season causes remarkable seasonal variations to occur in the environmental parameters as well as in primary and secondary production. (Kumaran and Rao, 1975; Pillai et al., 1975 and Silas and Pillai, 1975). Salinity acts as the major factor controlling the distribution of the organisms in the estuary. The seasonal variations induced by the monsoon directly affect the salinity distribution. The interrelation between the hydrographical parameters in the present case, showed tremendous influence of monsoon. However, the distribution of nutrients was found to be independent of hydrographical parameters, but they were influenced by the river discharge and land drainage. Joseph and Pillai (1975) indicated that salinity, though has apparently no influence on primary production in the estuary, is one of the important factors which controls the species composition and succession of phytoplankton. The present observation is also indicative of the distribution of marine and freshwater forms of phytoplankters according to different salinity regimes. Kumaran and Rao (1975) found that flowering of phytoplankton, soon after monsoon, in brackishwater is favoured by high nutrient concentration during monsoon and the same holds good here also. However, corresponding high in zooplankton production is not observed, thereby indicating that the phytoplankton is not proportionately converted into zooplankton in the ecosystem, as is also observed by Qasim (1970) and Pillai et al. (1975). The structure of association of various components of zooplankton is also indirectly linked with salinity because the stability of the niches is controlled by distribution of salinity. And according to Rao et al. (1975) and Silas and Pillai (1975), the distribution of various species undulated up and down in the estuary depending on the salinity variation.

Statistical analysis also showed significant correlation among the hydrobiological parameters (Table 28-31). The relation between the temperature and salinity is found to be significant at 1% level in station I, II, IV and at 5% level in station III. Among the four stations studied, station IV showed significant correlationship among the hydrobiological parameters. In this station, relationship between temperature and dissolved oxygen, temperature and pH, salinity and dissolved oxygen, and salinity and pH are found to be significant at 1% level. Station II also showed similar relationship between temperature and pH, and salinity and dissolved oxygen which are significant at 5% level.

Statistically, a significant correlation was also observed between the hydrographical parameters and the phytoplankton and zooplankton distribution. Temperature and salinity were found to be the prime factors contributing to the distribution of plankton. Temperature was found to have significant correlation with phytoplankton at 1% level in station I and IV and at 5% level in station II. No such relationship was observed between the salinity and phytoplankton in all the stations except at station IV, where it is significant at 5% level. Station IV also showed significant relationship between dissolved oxygen and phytoplankton and pH and phytoplankton which are not observed in other stations. A positive correlation was noticed between temperature and zooplankton, and salinity and zooplankton in all the four stations studied. However, there was no such significant correlation observed between phytoplankton and zooplankton, in all the stations except in station IV, where the correlation is significant at 5% level.

Even though a vast potential of brackishwater area is available in our country, a precise appraisal on the distribution and abundance of fry is wanting. However, the available information in this line indicates that the fry in general are dominant during premonsoon and monsoon season. Of all the cultivable brackishwater fishes, mullets are the most important group occurring in our estuaries followed by milk fish. The observations by Tampi (1968) in brackishwater environments in general, Shah (1975) in Kulti estuary, Basu and Pakrasi (1979) in Bakkhali areas of lower Sundarbans and Jayabalan et al. (1984) in Vellar estuary, indicate that the fry of mullets are distributed through out the year with the maximum abundance during premonsoon period. The investigation by Purushan (1989) at Puduvyepu, Cochin shows the presence of mullet fry throughout the year. The distribution pattern of fry of L. parsia and L. macrolepis observed during the present investigation also indicates an extended distribution throughout the period of study with the maximum abundance during premonsoon season. However, fry of M. cephalus was mainly abundant during early monsoon. Purushan (1989) correlates similar distribution pattern of M. cephalus observed at Puduvyepu, Cochin to a probable short spawning season of the species. Fry of C. chanos has been found distributed during February-June with peak abundance during April-May in Puduvyepu, Cochin (Purushan, 1989) and during April-May both in Pulicat lake (Rao, 1970) and in Bakkhali region of lower Sunderbans (Basu and Pakrasi, 1976) and in May in Vellar estuary (Jayabalan et al. (1984). Silas et al. (1985) observed the prolonged seasonal availability of milk fish fry along Kerala Coast, deleneating the peak period during March-June. During the present investigation also, the results obtained are similar to those of the earlier workers with their predominant occurrence during premonsoon. During the present study the leptocephalus like larvae of M. cyprinoides were found to be abundant during the premonsoon period which is in agreement with the work done by Purushan (1989).

An evaluatioin of the spatial distribution of the fry in general shows that they are abundantly distributed in station II and III, which may be due to their proximity to the barmouth compared to station I. While the absence of fry in station IV, during monsoon may be assigned to the disturbances due to tidal mixings, the least tidal influence and high freshwater influx may be the causes for the absence of fry in station I, during monsoon. While, this principle holds good for fry of mullets and milkfish, the leptocephalus like larvae of M. cyprinoides exhibit a different pattern of distribution. It is well known that the passive leptocephalus like larvae of M. cyprinoides get drifted along with the tidal current. Their presence in station II, III and IV, and their absence in station I may be thus attributed to the positive and negative influence of tide respectively.

A correlation of the distribution of fry in time and space with the hydrobiological parameters indicate certain interesting features. Salinity is found to have a profound influence on their distribution both directly and indirectly. Sarojini (1958) has found that fry of L. parsia was available during January-May at Hooghly-Matlah estuary. In the present observation also, fry of L. parsia and L. macrolepis were abundant during the premonsoon, during which period, high salinity condition favoured rich plankton production. Studies on the bionomous of the species shows that in the fry stage, L. parsia and L. macrolepis feed mainly on diatom and copepods (Bapat and Bal, 1952). A close scrutiny of the plankton production in the current investigation, also indicates that diatoms among phytoplankton and copepods among zooplankton were the most dominant groups especially in station II and III; thereby emphasising the influence of the favourite food on the distribution of major mullet seeds encountered. Thus it may be surmised that an environment providing characteristically favourable environmental parameters and enriched with the required food items, can be used as a index for the collection of mullet fry. The fry of M. cephalus was recorded during June to August with peak during July when the temperature and salinity showed comparatively low value. The fry of C. chanos were recorded during March-April in station II and IV, when the salinity and the temperature were high. Studies on the bionomics of the species show that the fry feed on phytoplankton only (Hiatt, 1944). Thus considering the abundance of phytoplankton in these stations, it was observed that the concentration is adequate enough to meet the demand by the fry during this period. The feeding habit of fry of M. cyprinoides shows that they feed on zooplankton, insects and fish fry (Alikunhi, 1957). The presence of larvae of M. cyprinoides during premonsoon season showed the direct relationship of abundance of these larvae with the zooplankton distribution. The temperature and salinity during this period of abundance were also found to be maximum thereby indicating the preference of fry of *M. cyprinoides*, to high temperature and high salinity.

Eventhough considerable attention has been diverted to understand the distribution of juveniles of cultivable fishes, most of the contributions evince a combined effort on the fry and juveniles together, or as seed in general (Rao and Gopalakrishnan, 1975; Basu and Pakrasi, 1979; Jayabalan *et al.*, 1984). The distribution of juveniles in the present case was found to vary considerably with time and space. Juveniles of *L. parsia* and *L. macrolepis* were found to be dominating throughout the year with a maximum abundance during premonsoon. Juveniles of *V. cunnesius*, *M. cephalus*, *C. chanos* and *M. cyprinoides* observed only after the onset of monsoon indicate the migration of these species to this ground during monsoon. Station II was found to be the richest ground in their distribution, followed by station III. From a correlation with the prevailing of hydrobiological factors, it was observed that the salinity and occurrence of phyto and zooplankton may be favourable for their distribution and abundance. Station I was found to be poor in distribution of juveniles than station II and III which might be due to the existance of low saline condition, and low concentration of phyto and zooplankton abundance. In station IV, the distribution was found to be minimum. The highly turbulent water during the monsoon and the highly dynamic nature of the intertidal zone, due to wave action, creating an unstable habitat may be the cause for the lesser distribution of juveniles in station IV. Further, the hapa net and cast net used as gear in the present study were found more effective in stations with mild current. Nevertheless, these gears were used in station IV also, with a view to maintain uniformity in gear implementation. Moreover, as Rao and Gopalakrishnan (1975) have stated, considerable gear research will have to be carried out since the type of gear to be selected for areas like estuaries, lagoons, and creeks have to cope up with physical factors like high degree of turbulance, tidal current, tidal amplitude and the reversal of current at the turn of the tide.

A statistical correlation of the various hydrographic parameters with the abundance of fry and juveniles in different stations showed that the distribution of fry has significant correlation with salinity at 1% level in station I & II and with dissolved oxygen at 5% level in station III. The distribution of juveniles was found significantly correlated with temperature and salinity at 5% level in station II and with temperature alone at 5% level in station III. But a positive correlation between the fry/juveniles and plankton was not evident probably because their preference to plankton was species specific. However, a significant correlation was observed between fry and juveniles at 5% level in station I and II. (Table 28-31).

The present study revealed the prevalence of profound diurnal variations in physical, chemical and biological regimes of the ecosystem. Observations by Shynamma and Balakrishnan (1973) in Cochin backwater, Singbal (1973) in Zuary estuary, Singbal (1976) in Mandovi estuary, and Vijayalakshmi and Venugopalan (1973) in Vellar estuary showed that temperature exhibited marked diurnal rhythm in its distribution with higher temperature during ebb tide and low temperature during high tide. However, in the present investigation, temperature was found independent of tidal fluctuations. The maximum temperature recorded during noon hours may be due to direct influence of sunlight and the resultant high atmospheric temperature. During the following hours, a gradual decrease in temperature was discernible with the minimum value recorded during early morning hours which might be due the prevailing low atmospheric temperature throughout the night. It may therefore be concluded that, apart from tidal influence, solar radiation also seems to be one of the causative factors for inducing diel variations of temperature as has also been observed by Pillai and Pillai (1973).

Salinity changes during a day are studied by several workers like Shynamma and Balakrishnan (1973), in Cochin backwater Singbal (1973) in Zuary estuary, Singbal (1976) in Mandovi estuary and Vijayalakshmi and Venugopalan (1973) in Vellar estuary. A direct relationship between the tide and salinity was observed by them. In the present study also, the changes in salinity was found to follow the tidal rhythm. The salinity values increased during flood tide and decreased during ebb tide, owing to the influx of seawater and efflux of freshwater respectively.

High value of dissolved oxygen obtained during the day time and low value during early morning hours, in the present investigation might be assigned to the photosynthetic activity during day time and community metabolism such as respiratory activities of the organisms during night hours respectively. The oxygen content of water appears to be independent of tide. Observations made by earlier workers indicated the similar fluctuation trend of surface dissolved oxygen concentration in Cochin backwater (Shynamma and Balakrishnan, 1973), in Zuary estuary (Singbal, 1973) and in Mandovi estuary (Singbal, 1976).

In the present case the changes in pH value were found to follow the tidal rhythm with the higher value during high tide and lower value during ebb tide. This may be corroborated with the influence of seawater influx which is of higher pH and influence of fresh water efflux which is of lower pH respectively.

The study on the diurnal variations of nutrients by

Shynamma and Balakrishnan (1973) in Cochin backwater, Singbal (1973) in Zuary estuary, Singbal (1976) in Mandovi estuary indicated that while nitrate and phosphate have no relationship with the tide, silicate showed a marked inverse relationship. However, Vijayalakshmi and Venugopalan (1973) in Vellar estuary found an inverse relationship of all the nutrients with the tide. In the present case also, the nutrients such as nitrite, nitrate phosphate and silicate showed an inverse relationship with the tide, with the concentration of all the nutrients to be low during high tide and increasing gradually reaching their maximum concentration during the ebb tide.

Phytoplankton cells in the four stations indicated a direct relationship with the rise and fall of the tide as was also observed in Vellar estuary by Rangarajan (1958) and Vijayalakshmi and Venugopalan (1983). The high concentration of phytoplankton found during high tide may be owing to the influence of high saline water of the sea which is rich in phytoplankton concentration, with the population dwindling during the low tide for obvious reasons. During high tide, the phytoplankton was mainly represented by Coscinodiscus spp., Navicula spp, Nitzschia spp., Rhizosolenia spp. Pleurosigma spp. and Gyrosigma spp., which might be due to the influence of seawater ingress; whereas the freshwater forms such as Oscillatoria sp. and Nastoc sp. contributed a larger share during the ebb tide and this may be due to heavy efflux of fresh-water from upstream.

The zooplankton also had its peak at the incoming high tide and receding tide. However, the lowest number was observed during highest high tide and lowest low tide. But the observation made by Vijayalakshmi and Venugopalan (1973) in Vellar estuary showed that the variations in zooplankton number more or less followed those of the tide with the minimum and maximum number coinciding with low and high water respectively. Copepods and decapode larvae were the important groups of zooplankton contributing to the maximum percentage throughout the day. Cladocerans showed an inverse relationship with the tide with the maximum number during ebb tide and minimum number during high tide, which might be due to the influence of freshwater from upstream and seawater from the sea respectively. In general, during night hours the zooplankton population was high, when compared to the day time which may be due to the vertical migration performed in pursuit of favourable temperature. Similar observations were also made by Vijayalakshmi and Venugopalan (1973) in Vellar estuary.

An overall review of the diel variations in the hydrobiological parameters indicated that tide was the major factor influencing the various hydrobiological factors such as salinity, pH, nutrients, phytoplankton and zooplankton. However, temperature and dissolved oxygen variations were found to be independent of tidal fluctuation. The vertical migration of zooplankton to the surface layer during night hours indicated the influence of the temperature on their distribution.

The abundance of fry of L. parsia, L. macrolepis and M. cephalus was the maximum during the incoming high tide, followed by a low during the receding tide. However, they were found to be minimum during highest high tide and lowest low tide. Similar type of observation was made by Basu and Pakrasi (1979) in Bakkhali areas, where hourly catches for first two/three hours from the onset of hightide of a day was considered and found decreasing towards the highest high tide. But James et al. (1984) observed the dominance of mullet fry during the receding high tide than during the other period. The information by them indicated that the seed of mullet enter into the estuary along with the tide. However, the distribution of M. cyprinoides during incoming high tide as well as during highest high tide may be due to the drifting nature of the leptocephalus like larvae by the tidal action.

With regard to the time of collection, it was observed that the abundance of fry as a whole was maximum during morning and evening hours when the temperature of water was relatively low thereby indicating the preference by the fry for low temperature. However, during the late night hours though the lowest temperature was recorded, the abundance of fry was found to be minimum which may be due to the influence of lowtide.

While a correlation with the environmental parameters, such as salinity, dissolved oxygen, pH and nutrients did not indicate any direct relationship, with the abundance of fry, the distribution of phytoplankton and zooplankton was found to have some influence on the diel distribution of fry. The least concentration of phyto and zooplankton was observed during the lowest low tide when the abundance to fry was also found to be minimum. Similarly, the maximum fry was recorded during the incoming high tide, when the zooplankton was found in their maximum concentration, with the phytoplankton in moderate quantities. However,the maximum concentration of phytoplankton was observed during the highest high tide, when the fry concentration was found to be low. The reason for this may be attributed to the probable increase in volume of water in unit area during highest high tide.

The juveniles were found to be abundant during lowest low tide which may be due to the shrinkage of water body and presence of high concentration of juveniles per unit area than during high tide. Besides, the juveniles were caught in maximum number during early morning hours when the temperature was low. The abundance of juveniles was found to be independent of salinity, dissolved oxygen and pH changes. Their distribution was also found to be independent of phyto and zooplankton concentration. To sum up, it was found that tide was the key factor controlling the distribution and abundance of juveniles.

Statistically, it was observed that among the parameters studied, tide is the key factor influencing all other parameters. The relationship of tide with temperature, salinity, dissolved oxygen and pH is found to be significant at 1% level. Similarly the temperature also showed a direct relationship with salinity, dissolved oxygen and pH, which are found to be significant at 1% level. The relationship between salinity and dissolved oxygen is significant at 5% level, whereas that between salinity and pH is significant at 1% level. Nutrients such as nitrate, phosphate and silicate showed a significant negative correlationship with the tide. During the study period, there was no significant inter-relationship observed between the hydrographical parameters and phytoplankton, zooplankton and fry distribution. However, there is a significant inverse relation observed between tide and juveniles distribution, which is found to be significant at 1% level. (Table 33).

From the foregoing discussion, it could be confirmed that Cochin backwater with its regular ingress of tides forms one of the potential nursery ground for a number of cultivable brackishwater fishes. The study enables us to throw some light on the influence of ecological regime on the distribution and abundance of fry and juveniles of these fishes. However, since the observations were restricted to a limited period of eight months covering a few representative stations, a complete conclusion in terms of time and space could not be drawn. Therefore, it is suggested that further steps are to be taken to have detailed study in this line on Cochin backwater in particular and the entire estuarine system of the country in general, envisaging a full fledged brackishwater fish seed industry to function in the country.

S U M M A R Y

The Cochin backwater system, the largest of its kind on the west coast of India, is important as a nursery ground for many of the cultivable finfishes and shellfishes. The present investigation aims to provide an accurate information on the distribution and abundance of fry and juveniles of cultivable fishes in relation to environmental parameters, such as rainfall, temperature, salinity, dissolved oxygen, pH, nitrite, nitrate, phosphate, silicate, phytoplankton and zooplankton, in Cochin backwater and the intertidal waters of the sea in the vicinity of Cochin.

2. The results and conclusions derived in the present investigation were based on the fortnightly variations in the abundance of fry and juveniles along with the environmental parameters. The investigations were carried out in four selected stations during February to September, 1989. Diurnal observations were made in two selected stations, during last day of July at every three hours interval to understand the influence of tide and other environmental parameters on the distribution of fry and juveniles. The results are statistically correlated with a view to bring out the possible correlations.

3. With a maximum in the month of June, the total rainfall received during the period of study was 227 cm, which is found to be much less compared to the average rainfall of 323 cm.

4. The water temperature was found to be within a narrow range of 28°C to 32.5°C, in all the stations throughout the study period. In general, a progressive decrease in surface temperature was observed with the onset of monsoon.

5. The salinity showed a decreasing trend with the increase in distance from barmouth to upstream. Wide fluctuations of salinity were observed during the present investigation in all the four stations, with the maximum during premonsoon and minimum during monsoon season.

6. The dissolved oxygen content did not show any general distribution pattern among the stations, with the maximum and minimum values recorded in different months. In general, station IV registered higher concentration of dissolved oxygen than the other three stations, throughout the study period.

7. The pH was found to be more during premonsoon and less during monsoon months in all the stations. With a maximum value in station IV and minimum in station I throughout the

investigation period, pH indicated a descending trend with the increase in distance from barmouth to head stream.

8. The concentration of all the nutrients such as nitrite, nitrate, phosphate and silicate was low during premonsoon but indicated a sharp increase during monsoon. The concentrations were decreasing again towards the end of the study period. Compared to other stations, a low content of nutrients was observed in station IV throughout the study period, where a maximum influence of seawater and minimum influence of freshwater run off were found to exist.

9. During the present study, phytoplankton showed maximum concentration during premonsoon and minimum during monsoon in station I, II and III, while in station IV, maximum concentration of phytoplankton was recorded during early monsoon. It was observed that the phytoplankton abundance was largely contributed by diatoms, such as Coscinodiscus spp., Skeletonema spp., Nitzschia spp., Navicula spp., Pleurosigma spp. etc. The freshwater algae also contributed to a larger share in station I, II and III, during monsoon. Few dinoflagellates were recorded in all the stations except in station IV, where these were noticed in a considerable number during premonsoon. Phytoplankton production was found influenced by environmental parameters like temperature and salinity.

10. Quantitatively, the number of zooplankton per unit volume was maximum during premonsoon in all the stations, but showed a declining trend with the onset of monsoon. Throughout the investigation period, the zooplankton was found to be maximum in station IV and minimum in station I. Qualitative analysis of zooplankton showed the population to have ten major groups, out of which copepods and decapod larvae were the most important ones. Hydromedusae, lucifer and brachiuran zoea were observed only during premonsoon in station II and IV, whereas cladocerans were recorded during monsoon in station I, II and III. Zooplankton production was not proportional to that of phytoplankton population.

11. Observarions on the abundance of fry showed that, the total number of fry per unit effort was maximum during premonsoon and early monsoon in station II, III and IV and the number was found to be decreasing to a greater extent during August and September. Station II and III were found to be richer in distribution of fry than station I and IV. Among the five species of fry recorded, Liza parsia was found to be dominant through out the study period followed by L. macrolepis. Fry of Mugil cephalus was recorded during the early monsoon in station II, III and IV, whereas fry of Chanos chanos was noticed during March-April in station II and IV. The leptocephalus like larvae of Megalops cyprinoides were dominant during

premonsoon in station II and IV. The size distribution of fry of different species showed that the smaller size ranging between 12-18 mm contributed the maximum percentage of the total fry caught except in M. cyprinoides, where the dominant size group was 24-26 mm, Distribution of fry was found influenced by factors like temperature, salinity, phytoplankton and zooplankton.

12. The distribution of juveniles in time and space showed that, they occur in more numbers during premonsoon; especially in station I, II and III. Station II was richer in abundance of juveniles followed by station III, among the four stations. L. parsia was the most dominant species recorded throughout the year followed by L. macrolepis. The distribution of juveniles was found to be reflective of fry distribution. The juveniles of other important species, such as M. cephalus, Valamugil cunnesius, C. chanos, M. cyprinoides, Lates calcarifer etc. were recorded in few numbers with the onset of monsoon. The size distribution of juveniles varied from species to species. The occurrence of juveniles was maximum during the lowest low tide, when the number of juveniles per unit area was found to be maximum which is due to the shrinkage of water area.

13. The diurnal observation showed a tremendous influence of tides on the distribution of fry and juveniles and other hydrobiological parameters. The tides of Cochin backwater

were of mixed semidiurnal type, with substantial difference in range and time. Water temperature recorded its lowest value during the early morning with the highest value during noon hours probably influenced by solar radiation. Salinity showed a direct relationship with tide, with maximum salinity during high tide and minimum during low tide. Dissolved oxygen content was found to be independent of tidal amplitude, recording high concentration during afternoon and low during early morning. pH value showed a direct relationship with the tide, though within a narrow range. The concentration of all the nutrients showed an inverse relationship with the tide, with a maximum concentration during ebb tide and minimum during flood tide.

The phytoplankton concentration was found to be in proportion with the tide. The lowest concentration recorded during low tide, which increased gradually, reaching the maximum value during high tide. Qualitatively, the phytoplankton showed the dominance of marine forms during high tide and fresh water algae during ebb tide.

A wide fluctuation of zooplankton concentration was noticed by the influence of tide, with maximum number during incoming high tide and receding tide, and minimum during highest high tide and lowest low tide. The number was found to be more in night time than during day time which may be due to their vertical migration. Copepods and decapods larvae were the two most important groups among the zooplankton encountered.

Among the four species of fry recorded during the present study, L. parsia was the most dominant species, followed by M. cephalus and L. macrolepis. M. cyprinoides also was recorded in few numbers during the high tide. The abundance of fry was maximum during morning and evening hours than during afternoon and late night hours. The incoming high tide showed the dominance of fry followed by receding tide.

The distribution of juveniles was inversely proportional to the tide, with maximum during low tide and minimum during high tide. L. parsia was the most dominant species recorded, followed by L. macrolepis. Sporadic catch of other species was also obtained.

14. This investigation on the fish seed availability in Cochin backwater is only a partial fulfillment of our requirement in the field of brackishwater fish seed procurement, and it is suggested that similar studies may be taken up in other estuaries and brackishwater bodies in the country.

REFERENCES

ABRAHAM, S 1970a. On the occurrence and seasonal distribution of Acartia plumosa T. Scott (Copepoda: Calanoida) a new record from the west coast of India. Curr. Sci.,39(5): 115-116.

*ABRAHAM, S 1970b. A new species of Acartia(Copepoda:Calanoida) from Cochin Harbour, India, and adjacent areas. Crustacean 18(1): 49-55.

ALIKUNHI, K.H. 1957. Fish culture in India, Farm Bull., Indian Coun. agric. Res., 20: 144 pp.

*ANON, 1965. Report on Fish spawn prospecting investigations, 1964, 1. Uttar Pradesh and Gujarat. Bull. Cent. Inl. Fish. Res. Inst. Barrackpore, 4: 191 pp.

ARMSTRONG, F.A.J. and H.W. HARVEY, F.R.S., 1950. The cycle of phosphorus in the waters of the English Channel. J. Mar. Biol. Ass. UK, 29: 145-162.

BAL, D.V. and L.B. PRADHAN 1951. Occurrence of fish larvae and postlarvae in Bombay waters during 1944-47. J. Univ. Bombay, New series, Sec. B, Part 3, 20: 1-15.

BALAKRISHNAN, A. 1957. Variations in salinity and temperature in Ernakulam channel. Bull. Cent. Res. Univ. Kerala, 5: 7-9.

BALAKRISHNAN, K.P. and C.S. SHYNAMMA 1976. Diel variations in Hydrographic conditions during different seasons in the Cochin Harbour (Cochin backwater). Indian J. Mar. Sci., 5(2): 190-195.

BAPAT, S.V. and D.V. BAL 1952. The food of some young fishes from Bombay. Proc. Indian Acad. Sci., (B), 35(2): 78-92.

BASU, N.C. and B.B. PAKRASI 1976. On the occurrance of milk fish, Chanos chanos (Forskål) larvae in the Bakkhali region of lower sunderbans. J. Inland Fish. Soc. India., 8: 97-104.

BASU, N.C. and B.B. PAKRASI 1979. Brackish water fish and prawn seed potentialities of Bakkhali area in lower Sunderbans, West Bengal. J. Inland Fish. Soc. India, 11(1): 40-48.

BHANOT, K.K. 1971. Observations on the availability of brackish-water fish seed in the Matlah estuary around Port Canning. J. Mar. biol. Ass. India, 13(2): 274-278.

BHANOT, K.K. and V. GOPALAKRISHNAN 1972. Observations on the collection of fry of the mullet, Mugil parsia (Hamilton) with standard spawn collection nets. J. Inland Fish.Soc. India, 4: 205-206.

BRAVE, S.K. and D.R. JALIHAL 1987. Seed identification of of four species of mullets off Ratnagiri, West Coast of India. J. Mar. biol. Ass. India, 29(1 & 2): 158-169.

CHANDRAMOHAN, P. and T.S. RAO 1972. Tidal cycle studies in relation to zooplankton distribution in the Godavari estuary, Proc. Indian Acad. Sci., LXXV (1): 23-31.

CHERIAN, P.V. 1967. Hydrological studies on and around the Cochin Harbour. Bull. Dept. mar. biol. Oceanogr., Univ. Kerala, 3: 9-17.

CHIDAMBARAM, K. and G.K. KURIYAN 1952. Notes on the grey mullets (Mugil spp.) of Krusadai Island, Gulf of Mannar J. Bombay nat. Hist. Soc., 50(3): 515-519.

DEHADRAI, P.V. 1970. Changes in the environmental features in Zuari and Mandovi estuaries in relation to tides. Proc. Indian Acad. Sci., 72(2B): 68-80.

DEVASSY, V.P. and P.M.A. BHATTATHIRI 1974. Phytoplankton ecology of Cochin backwaters. Indian J. Mar. Sci. 3: 46-50.

DEVASUNDARAM, M.P. 1954. A report on the Fisheries of Chilka Lake from 1948-1952, 34p Cuttak: Orissa Govt.Press.

FISCHER, W. and G. BIANCHI, 1984. FAO Species identification sheets for fishery purposes. Western Indian Ocean (Fishing area 51). FAO, Rome.

GEORGE, M.J. 1958 Observations on the plankton of the Cochin Backwater. Indian. J. Fish., 5: 374-401.

GEORGE, M.J.and K.N. KRISHNA KARTHA 1963. Surface salinity of Cochin backwater with reference to tide. J. Mar. biol. Ass. India, 5(2): 178-184.

GOPALAKRISHNAN, V. 1968. Collection of brackish water fish seed from Hooghly estuary. Proc. Seminar on Production of Quality fish seed for fish culture. CIFRI, Barrackpore, 1-2 Nov. 1968: 232-247.

GOPALAKRISHNAN, V., K.K. BHANOT, S.N. DATTA and S.B. SAHA 1975. Procurement of stocking material for brackishwater fish culture from the Hooghly-Matlah estuarine system. J. Inland Fish. Soc. India, 7: 216-224.

GOPINATHAN, C.P. 1972. Seasonal abundance of phytoplankton in the Cochin backwater. J. Mar. biol. Ass. India, 14(2): 568-577.

GOPINATHAN, C.P. 1981. Studies on phytoplankton in the estuarine and marine environment. Ph.D. thesis, University of Cochin.

GOSWAMI, S.C., R.A. SELVAKUMAR and USHA GOSWAMI, 1979. Diel and tidal variation in zooplanktonic populations in the Zuari estuary, Goa. Mahasagar Bull. Natn. Inst. Oceanogr., 12(4): 247-258.

HARIDAS, P., M. MADHUPRATAP and T.S.S. RAO, 1973. Salinity temperature, oxygen and zooplankton biomass of the backwater from Cochin to Alleppey. Indian J. Mar. Sci., 2(2): 94-102.

*HIATT, R.W. 1944. Food chains and food cycle in Hawaiian fish ponds II. Biotic interaction, Trans Amer. Fish. Soc., 74: 262-280.

JAMES, P.S.B.R., V.S.RENGASWAMY, A. RAJU and G. MOHANRAJ, 1984. Studies on diurnal variation in the occurrance pf Grey mullet seed at Mandapam. Proc. Symp. Coastal Aquaculture, III: 765-775.

JAMES, P.S.B.R., V.S. RENGASWAMY, A. RAJU and G. MOHANRAJ 1984. Studies on diurnal variation in the occurrance of Grey mullet seed at Mandapam. Proc. Symp. Coastal Aquaculture, III: 765-775.

JAYABALAN, N., G.S. THANGARAJ and K. RAMAMOORTHI 1984. Finfish seed resources of Vellar estuary, Proc. Symp. Coastal Aquaculture, III: 742-749.

JAYALAKSHMY, K.V., S. KUMARAN and M. VIJAYAN, 1986. Phytoplankton distribution in Cochin backwaters. A seasonal study. Mahasagar Bull. Natn. Inst. Oceanogr., 19(1): 29-37.

JHINGRAN, V.G. 1983. Fish and Fisheries of India. Hindustan Publishing Corporation (India). Delhi, 666 pp.

JOSANTO, V. 1971. The bottom salinity characteristics and the factors that influence the salt water penetration in the Vembanad Lake. Bull. Dept. mar. biol. Oceanogr. 5:1-16.

JOSEPH, K.J. and V. KUNJUKRISHNA PILLAI 1975. Seasonal and spatial distribution of phytoplankters in Cochin backwaters. Bull. Dept. Mar. Sci., Univ. Cochin 7(1): 171-180.

KUMARAN, S., T.S.S. RAO 1975. Phytoplankton distribution and abundance in the Cochin backwaters during 1971-1972. Bull. Dept. Mar. Sci. Univ. Cochin 7(4): 791-799.

KUO, C.M., Z.H.SHEHADEH and C.E.NASH 1973. Induced spawning of captive grey mullet. (Mugil cephalus L.) females by injection of human chorionic gonadotropin(HCG).Aquaculture 1: 429-432.

LAKSHMANAN, P.T., C.S. SHYNAMMA, A.N. BALCHAND and P.N. NAMBISAN, 1987. Distribution and variability of Nutrients in Cochin Backwaters; South West Coast of India. Indian J. Mar. Sci., 16(2): 99-102.

LIAO, I-CHIU, Y.J.LU, T.L. HUANG and M.C. LIN 1972. Experiments on induced breeding of grey mullet Mugil cephalus Linnaeus. Aquaculture in the Indo-Pacefic Region: 213-234.

MADHUPRATAP, M. and P. HARIDAS 1975. Composition and variations in abundance of zooplankton of backwaters from Cochin to Alleppey, Indian J. Mar. Sci., 4: 77-85.

MADHUPRATAP, M., T.S.S. RAO and H. KRISHNA IYER 1977. A model for the prediction of zooplankton abundance in an estuary. Indian J. Mar. Sci. 6(2): 183-184.

MADHUPRATAP, M. 1978. Studies on the ecology of zooplankton of Cochin backwaters. Mahasagar Bull. Natn. Inst. Oceanogr 11(1 & 2): 45-46.

MADHUPRATAP, M. and T.S.S. RAO 1979. Tidal and diurnal influence on estuarine zooplankton. Indian J. Mar. Sci.,8(1): 9-11.

* MARTIN, D.F. 1968. Marine Chemistry. Analytical methods. Marcel Dekker, INC, New York. Volume 1.

MENON, N. RAVINDRANATH, P. VENUGOPAL and S.C. GOSWAMI 1971. Total biomass and faunistic composition of the zooplankton in the Cochin backwater. J. Mar. biol. Ass. India. 13(2): 220-225.

MOHAMMED, K.H. and P. VEDAVYASA RAO 1972. Estuarine phase in the life history of the commercial prawns of the west coast of India. J. mar. biol. Ass. India, 13(2): 149-161.

*MORTIMER, C.H. 1941. J. Ecol. 29: 280.

MPEDA, 1980. Assessment of fry resource of cultivable penaeid prawns at selected centres in Kerala and Karnataka. CMFRI Project Report, 84 pp.

MUKHOPADHYAY, M.K., and P.U. VERGHESE 1978. Observations on the larvae of Lates calcarifer (Bloch) from Hooghly-Matlah estuary with a note on their collection. J. Inland Fish. Soc. India, 10: 138-141.

NAIR, K.K. CHANDRASEKHARAN and D.J. TRANTER, 1971. Zooplankton distribution along salinity gradiant in the Cochin backwater before and after monsoon. J. Mar. biol. Ass. India. 13(2): 203-210.

NAIR, N., BALAKRISHNAN, P.K. ABDUL AZIS, K. DHARMARAJ, M. ARUNACHALAM, K. KRISHNA KUMAR and N.K. BALASUBRAMANIAN 1983. Ecology of Indian Estuaries: Part-I Physico-chemical features of water and sediment nutrients of Ashtamudi estuary. Indian J. Mar. Sci. 12(3): 143-150.

NAIR, N. BALAKRISHNAN and P.K. ABDUL AZIS, 1987. Ecology of Ashtamudi estuary, South West Coast of India, J. Mar. biol. Ass. India, 29(1 & 2): 177-194.

NAIR, VIJAYALAKSHMI R. 1972. Seasonal fluctuations of chaetognaths in Cochin Backwater. J. mar. biol. Ass. India, 13(2): 226-233.

PARSON, R. TIMOTHY, YOSHIAKI MAITA, CAROL M. LALLI 1984. A manual of chemical and biological methods for sea water analysis, Pergamon press, Oxford, 283 pp.

PILLAI, P. PARAMESWARAN 1970. Pseudodiptomus jonesi, a new Calanoid Copepod from Indian waters. Curr. Sci., 39(4), 78-80.

PILLAI P. PARAMESWARAN 1972. Studies on the estuarine copepods of India. J. mar. biol. Ass. India, 13(2): 162-172.

PILLAI PARAMESWARAN P. and M. AYYAPPAN PILLAI 1973. T idal influence in the diel variations of zooplankton with special reference to copepods in Cochin backwaters. J.. Mar. biol. Ass. India: 15(1): 411-417.

PILLAI P. PARAMESWARAN, S.Z. QASIM and A.K.K. NAIR 1973. Copepod component of zooplankton in a tropical estuary. Indian J. mar. sci., 2(2): 38-46.

PILLAI V.K., K.J. JOSEPH and A.K. KESAVAN NAIR 1975. The plankton production in the Vembanad lake and adjacent waters in relation to environmental parameters. Bull. Dept. Mar. Sci., Univ. Cochin. 7(1): 137-150.

PURUSHAN, K.S. 1989. Puduvyepu: A potential brackish water fish seed resource. Fishing Chimes February, 1989: 63-66.

QASIM, S.Z. and C.V.G. REDDY 1967. The estimation of plant pigments of Cochin Backwater during the monsoon months. Bull. Mar. Sci., Gulf of Carribb., 17(1): 95-110.

QASIM, S.Z. and C.P. GOPINATHAN 1969. Tidal cycle and the environmental features of Cochin backwater (a tropical estuary) Proc. Indian Acad. Sci. 69-B(6): 336-348.

QASIM, S.Z. 1970. Some problem related to the food chain in a tropical estuary. "Marine food chains" ed. J.H. Steele. Oliver and Boyd, Edinburgh.

RAJYALAKSHMI, T. 1980. Manual of Brackish water aquaculture in India. Bull. CIFRI (ICAR), Barrackpore, 31: 128 pp.

RAMADHAS, V. 1977. Studies on phytoplankton, nutrients and some trace elements in Porto Novo waters. Ph.D. Thesis, Annamalai University, India, 135 pp.

RAMAMIRTHAM, C.P. and R. JAYARAMAN 1963. Some aspects of the hydrographical conditions of the backwaters around Willington Island (Cochin). J. Mar. biol. Ass. India. 5(2): 170-177.

RANGARAJAN, K. 1958. Diurnal tidal cycle in the Vellar estuary J. Zool. Soc., India, 5(2): 54-67.

RANGASWAMY, C.P. 1978. A note on the fry of Liza vaigiensis (Quoy and Gaimard). J. Inland Fish. Soc. India., 10: 135-137

RANGASWAMY, C.P. 1985. On the identification of fry of frey mullet Valamugil cunnesius (Valenciennes). Proc. Symp. Coastal Aquaculture, MBAI, 3: 970-975.

RAO, A.V. PRABHAKARA 1970. On the seasonal abundance of larvae and juveniles of cultivable brackishwater fish in the Pulicat Lake. Indo-Pacific Fish. Coun.,14th Session, IPFC/C 70/Sym 30: 23 p. (Mimeo).

RAO, A.V. PRABHAKARA 1971. Observations on the larval ingress of the milk fish Chanos chanos(Forskal) in Pulicat lake J. Mar. biol. Ass. India, 13(1,2): 249-257.

RAO, A.V. PRABHAKARA and V. GOPALAKRISHNAN, 1975. Seed resources and bionomics of culturable brackishwater fishes of India. J. Inland Fish. Soc. India, 7: 142-155.

RAO, N.G.S. 1964. On the distribution of larvae, postlarvae and juveniles of fishes in the Mahanadi estuary. Indian J. Fish. 11A(1): 407-422.

RAO, T.S.S., M. MADHUPRATAP and P. HARIDAS, 1975. Distribution of zooplankton in space and time in a tropical estuary. Bull. Dept. Mar. Sci. Univ. Cochin 7(4): 695-704.

RAVISH CHANDRA 1962. A preliminary account of the distribution and abundance of fish larvae in Hooghly estuary. Indian J. Fish., 9: 48-70.

RENGARAJAN K. and I. DAVID RAJ 1979. On ichthyoplankton of the Cochin backwater during spring tides. J. Mar. biol. Ass. India, 21(1&2): 111-118.

RITTENBERG, S.C., K.O. EMERY and WILSON L. ORR 1955. Regeneration ofnutrients in sediments of marine basins. Deep-sea Res. 3: 23-45.

SANTHAKUMARI, V. and M. VANNUCCI 1972. Monsoonal fluctuations in the distribution of the hydromedusae in the Cochin Backwater, 1968-1969. J. Mar. biol. Ass. India, 13(2): 211-219.

SANTHANAM, R., K. KRISHNAMURTHY and V. SUNDARARAJ 1975. Quantitative plankton ecology. Bull. Dept. Mar. Sci., Univ. Cochin, 7(4): 769-779.

SAROJINI, K.K. 1958. On the collection, Acclimatisation and transport of mullet seed in West Bengal (India). J. Bombay nat. Hist. Soc., 55(1): 42-53.

SHYNAMMA, C.S. and K.P. BALAKRISHNAN 1973. Diurnal variation of some physico-chemical factors in Cochin backwater during South West monsoon J. Mar. biol. Ass. India, 15(1): 391-398.

SILAS, E.G., and P. PARAMESWARAN PILLAI 1975. Dynamics of zooplankton in a tropical estuary (Cochin backwater) with a review on the plankton fauna of the environment, Bull. Dept. Mar. Sci., Univ. Cochin, 7(2) 329-355.

SILAS, E.G., G. MOHANRAJ, V. GANDHI and A.R. THIRUNAVUKKARASU 1984. Spawning grounds of the milk fish and seasonal abundance of the fry along the east and south west coast of India. Proc. Symp Coastal aquaculture. 3: 916-932.

SINGBAL, S.Y.S. 1973. Diurnal variations of some physico-chemical factors in the Zuari estuaries of Goa. Indian J. Mar. Sci., 2(2): 90-93.

SINGBAL, S.Y.S., 1976. Diurnal variation of some physico-chemical factors in the Mandovi estuary of Goa. Mahasagar Bull Natn. Inst. Oceanogr., 9(1&2): 27-34.

SNEDECOR, G.W. and W.G. COCHRAN, 1967. Statistical methods. 6th ed. Iowa State Univ. Press, Okva., Norman. 120 pp.

SREEDHARAN, MANIKOTH and K.Y. MOHAMMED SALIH 1974. Distribution characteristics of nutrients in the estuarine complex of Cochin. Indian J. mar. Sci., 3(2): 125-130.

SRINIVASAN, M 1972. Biology of chaetognaths of the estuarine waters of India. J. Mar. biol. Ass. India,13(2): 173-181.

STRICKLAND, J.D.H. and T.R.PARSONS 1968. A practical hand book of Seawater Analysis, Bull. 167, Fish. Res. Bd. Canada.

SUBRAMANIYAN,M. 1965. Lunar, Diurnal and tidal periodicity in relation to the prawn abundance and migration in the Godavari estuarine system. Fish. Tech., 2(1): 26-41.

TAMPI, P.R.S., 1968. Cultivable marine fish fry resources from brackishwater environments. CMFRI. Proc. Symp. Living resources of the Seas around India: 390-397.

THAKUR, N.K. 1975. Observations on the availability of brackish-water fish seed in Kulti estuary, West Bengal J. Inland Fish. Soc. India 7: 105-108.

VIJAYALAKSHMI, G.S. and V.K.VENUGOPALAN, 1973. Diurnal variation in the physico-chemical and biological properties in Vellar estuary. Indian J. Mar. Sci., 2(1): 19-22.

WELLERSHAUS, S 1969. On the taxonomy of planktonic copepoda in Cochin backwater (A South Indian Estuary) Veroeff. Inst. Meeres forsch. Bremerhaven, 11(2), 245-286.

WELLERSHAUS, S 1970. On the taxonomy of some copepoda in Cochin Backwater (a South Indian estuary). Veroeff. Inst. Meeres forsch. Bremerhaven 12: 463-490.

WELLERSHAUS, S. 1973. On the hydrography of the Cochin backwater (A South Indian estuary). J. Mar. biol. Ass. India 14(2): 487-495.

* Not referred in original.